Established by BENJAMIN SILLIMAN in 1818.

THE AMERICAN JOURNAL OF SCIENCE.

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THIRD SERIES.

VOL. XXXV.—[WHOLE NUMBER, CXXXV.]

No. 207—MARCH, 1888.

NEW HAVEN, CONN.: J. D. & E. S. DANA.
1888.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

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THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ASA GRAY

OUR friend and associate, Asa Gray, the eminent botanist of America, the broad-minded student of nature, ended his life of unceasing and fruitful work on the 30th of January last. For thirty-five years he has been one of the editors of this Journal, and for more than fifty years one of its contributors; and through all his communications there is seen the profound and always delighted student, the accomplished writer, the just and genial critic, and as Darwin has well said, "the lovable man."*

Asa Gray was born on the eighteenth day of November, 1810, at Sauquoit, in the township of Paris, Oneida County, New York, a place nine miles south of Utica. When a few years old, his father moved to Paris Furnace, and established there a tannery; and the child, one account says, was put to work feeding the bark-mill and driving the horse, and another, riding the horse that ground the bark. "At six or seven he was

* In the preparation of this sketch I have been much aided by the papers of Prof. Goodale, Prof. Sargent and Prof. C. R. Barnes, the last in the *Botanical Gazette* for January, 1886.

a champion speller in the numerous 'matches' that enlivened the District school." At the age of eleven, nearly twelve, he was sent to the Grammar school at Clinton, where he remained for two years, and the following year, to the Fairfield Academy, both of the schools places where all the classics and mathematics were taught that were required for entering the colleges of the land. But his instruction was cut short by his father's desire that he should enter the Fairfield Medical School. This school, of high repute, was established at that place in 1812, as the College of Physicians and Surgeons of the Western District of New York. Dr. James Hadley was the Professor of Chemistry and Materia Medica, and his lectures of 1825–6, while Gray was in the Academy, and 1826–7, after he had taken up medicine, gave the young student his first instruction in science. During the following winter at Fairfield, that of 1827–8, the article on Botany in the Edinburgh Encyclopædia attracted young Gray's attention, and excited his interest so deeply that he at once bought a copy of "Eaton's Botany" and longed for spring. As spring opened, "he sallied forth early, discovered a plant in bloom, brought it home and found its name in the Manual to be *Claytonia Virginica*, the species *C. Caroliniana*, to which the plant really belonged not being distinguished then." From this time, collecting plants became his chief pleasure. He finished his medical course, and, in the spring of 1831, took his degree of Doctor of Medicine—to him the basis for a title, but not for future work.

This ended his school and college days. As Gray's scientific education was carried forward without the aid of a formal scientific school, so it was with his literary studies. He had not the benefit of university training, and yet became eminent for his graceful and vigorous English, the breadth of his knowledge, his classical taste, and the acuteness of his logical perceptions.

Before the close of the medical course, he had opened correspondence about his plants with Dr. Lewis C. Beck, a prominent botanist of Albany, and had had a collection named for him by Dr. John Torrey of New York. Moreover, about this time, he delivered his first course of lectures on Botany, as substitute for Dr. Beck, and made use of the fees that he

received for the expenses of a botanical excursion through western New York to Niagara Falls. Gray also delivered a course of lectures at Hamilton College, Clinton, on mineralogy and botany, for Prof. Hadley, in the college year of 1833–4, a biographical sketch of Prof. Hadley, of Fairfield, by his son, the eminent Professor of Greek at Yale, stating that his father, who gave up his lectures at this college in 1834, "supplied his place during the last term by a favorite pupil and much valued friend, Dr. Asa Gray, who commenced under Professor Hadley the studies which were to make him preëminent among the botanists of his time." Prof. Hadley, the sketch says, had studied botany at New Haven, Ct., in 1818, under Dr. Eli Ives, an excellent botanist of that place, and mineralogy and geology under Prof. Silliman

In the autumn of 1831, Gray became Instructor in chemistry, mineralogy and botany at "Bartlett's High School" in Utica. The scientific department of the school had been under the charge of a graduate of Eaton's "Rensselaer School," at Troy—the earliest school of science in America—and Professor Eaton's practical methods of instruction in chemistry, mineralogy and botany were there followed. Great was the delight of the boys in botanical and mineralogical excursions with Mr. Fay Egerton, and their pleasure, too, in the lectures on chemistry. In 1830, the writer left the Utica High School for Yale College; and a year later, Mr. Egerton having resigned on account of his health, Gray took his place. We had then no acquaintance and knew nothing of one another's interest in minerals and plants. My minerals and herbarium went with me to New Haven; and while I was there Gray was mineralizing as well as botanizing, during his vacations, in New Jersey and western and northern New York. His first published paper is mineralogical—an account of his discoveries (along with Dr. J. B. Crawe) of new mineral localities in northern New York. It is contained in the twenty-fifth volume of this Journal,* and the title gives Utica as his place of residence. He had previously made

*Page 346. The article is in the second number of the volume, which was issued January 1st, and is without date; the one following it is dated Sept. 6, 1833. The paper therefore was probably written in the autumn of 1833, after a summer's excursion.

excursions after plants, fossils and minerals in New Jersey, and in 1834, joined Dr. Torrey in botanizing, besides collecting for him in the "pine barrens" of New Jersey and other places.

In the autumn of 1834, Gray accepted the position of assistant to Dr. Torrey in the chemical laboratory of the Medical School of New York. Botany was at first his study *under* Dr. Torrey, but soon his work *with* Dr. Torrey; and here commenced their long-united labors and publications. From the first he showed himself an adept in his methods of investigation and in his terse and mature style of scientific description. During the year 1834, while Torrey was preparing his monograph on the North American sedges, the Cyperaceæ, Gray had in hand an illustrated memoir on the genus Rhynchospora, in which he doubled the number of known North American species; and another also on "New, rare, and otherwise interesting plants of northern and western New York." Both papers were read before the Lyceum of Natural History of New York in December of that year (1834), and are published in volume iii of the Annals of the Lyceum. Dr. Torrey's monograph was read on the 8th of August, 1836; and in it he says that the part on the genera Rhynchospora and Ceratoschœnus was prepared by Dr. Gray, and that his descriptions are so full that he gives only his list of the species with such alterations as he has thought it advisable to make, and some additional matter received since the publication of his paper. During 1834, 1835, two volumes of a work on North American Gramineæ and Cyperaceæ were issued by him, each containing a hundred species, and illustrated by dried specimens—now rare volumes, as only a small edition was published through private subscription. The first of these volumes, issued in February, 1834, only three years after his graduation at the Fairfield Medical School, is dedicated to his instructor and friend, Dr. James Hadley. The preface acknowledges his indebtedness to Dr. Torrey and to Dr. Henry P. Sartwell of Penn-Yan. Of the species described as new in the work, the first one, No. 20, from specimens collected by Dr. Sartwell, turned out to be Nuttal's *Calamagrostis confinis*. But the next one, No. 28, *Panicum xantho-*

physum, from the vicinity of Oneida Lake, stands, and is the first of the thousands of good Asa-Gray species. Thus Gray's botanical investigations were well begun before his twenty-fifth year had passed.

In February or March of 1835 he gave his last instruction at the Utica High School. He expected to continue as Dr. Torrey's assistant the following season; but "the prospects of the Medical School were so poor that Dr. Torrey could not afford to employ him." He nevertheless returned to New York in the autumn, took the position of curator and librarian of the Lyceum of Natural History, and continued his botanical investigations. During the summer he had begun the preparation of his "Elements of Botany," and in the course of 1836 the work appeared. It showed the scholar in its science and in its style. The subjects of vegetable structure, physiology and classification were presented in a masterly manner, though within a small compass. The book, moreover, showed his customary independence of judgment and clear head in various criticisms and suggestions—later investigations sustaining them, much to his gratification.

The Wilkes Exploring Expedition came near making a profound impression on Gray's life. In the summer of 1836 the position of Botanist in the expedition was offered him, and accepted. But delays occurred in the time of sailing, and changes were threatened that threw uncertainties over the cruise, and for these reasons, and on account of the work on the North American Flora, of which, by invitation of Dr. Torrey, he was to be joint author, his resignation was sent in the following year. The expedition changed its commander from Commodore Patterson over a ship of the line, to Lieutenant Charles Wilkes with a squadron of two sloops of war (better adapted for the purpose), besides other vessels, six in all, and sailed in August, 1838. The four years abroad would have given him an opportunity for observations and discoveries that would have rejoiced him—excursions in Madeira, the Canaries, to the Organ Mountains in Brazil, a brief look about Orange Bay near Cape Horn, excursions to the Andes of Chili and about lower Peru, over Oregon and Washington territory, and parts of California, through numerous island groups of the South and North Pacific, in Australia and New Zealand, about

Luzon in the Philippines, at Singapore, at Cape of Good Hope and St. Helena—and his open mind would have gathered in facts on the relations and geographical distribution of species that would have been to him a mine of wealth as science advanced under Darwin's lead. The place of botanist in the expedition was well occupied by the most excellent, indefatigable and many-sided zoologist, Dr. Charles Pickering, and by Mr. Wm. D. Breckenridge, a Scotch gardener and zealous collector, and Mr. Wm. Rich; but with Dr. Gray, devoted to the one subject, great results would have been accomplished. North American botany, however, would no doubt have suffered.

By October of 1838, a couple of months after the sailing of the Exploring Expedition, two parts of the projected "Flora" were already out. But so many doubtful points had been brought to light, that a study of foreign herbaria had become imperative. Dr. Gray had accepted, during the summer, the chair of botany in the recently founded University of Michigan, but with the condition that he should have a year abroad for study; and the year was given to this object. All the herbaria of Europe were carefully examined with regard to the type-specimens of American plants, and full notes taken for use in the discrimination and identification of species. The fortieth volume of this Journal (April, 1841) opens with a highly interesting paper by him, giving accounts of these herbaria, their contributors, condition, and special characters, commencing with that of Linnæus and the story of its career before reaching the Linnean Society of London. His labors abroad involved an immense amount of detailed and exact observation, requiring thorough knowledge, excellent judgment, and a retentive memory; and he came home well stored for the work which he and Torrey had in hand.

Moreover, he made during the trip the personal acquaintance of the leading botanists of England and the Continent, and had from all a cordial reception.

"In Glasgow he made the acquaintance of William Jackson Hooker, the founder of the greatest of all herbaria, the author of many works upon botany, who had already published a large part of his "Flora Boreali-Americana," in which were described the plants of British North America, a work just then of special

interest to the young American, because it first systematically displayed the discoveries of David Douglas, of Drummond, Richardson, and other English travelers in North America. At Glasgow, too, was laid the foundation for his lifelong friendship with the younger Hooker, then a medical student seven years his junior, but destined to become the explorer of New Zealand and Antarctic floras, the intrepid Himalaya traveler, the associate of George Bentham in the authorship of the "Genera Plantarum," a president of the Royal Society, and, like his father, the director of the Royal Gardens at Kew. At Edinburgh he saw Greville, the famous cryptogamist; while in London, Francis Boott, an American long resident in England, the author of the classical history of the genus "Carex," and at that time Secretary of the Linnean Society, opened to him every botanical door. Here he saw Robert Brown, then the chief botanical figure in Europe, with the exception, perhaps, of De Candolle; and Menzies, who fifty years before had sailed as naturalist with Vancouver on his great voyage of discovery; and Lambert, the author of the sumptuous history of the genus "Pinus," in whose hospitable dining-room were stored the plants upon which Pursh had based his North American Flora. Here, too, he met Bentham and Lindley and Bauer, and all the other workers in his scientific field.

"A visit to Paris brought him the acquaintance of the group of distinguished botanists then living at the French capital: P. Barker Webb, a writer upon the botany of the Canaries; the Baron Delessert, Achille Richard, whose father had written the Flora of Michaux; Mirbel, already old, but still actively engaged in investigations upon vegetable anatomy; Spach; Decaisne, then a young *aide naturaliste* at the Jardin des Plantes, of which he was afterward to become the distinguished Director; Auguste St. Hilaire, the naturalist of the Duke of Luxembourg's expedition to Brazil, and at that time in the full enjoyment of a great reputation earned by his works upon the Brazilian flora; Jacques Gay; Gaudichaud, the naturalist of the voyage of L'Uranie and La Physicienne; the young Swiss botanist, Edmond Boissier, the Spanish traveler, and, later, one of the most important contributors to systematic botany in his classical "Flora Orientalis;" Adrien de Jussieu, grand-nephew of Bernard, and

son of Laurent de Jussieu, himself a worthy and distinguished representative of a family unequalled in botanical fame and accomplishment.

"At Montpellier, Dr. Gray passed several days with the botanists Delile and Dunal, and then hurried on to Italy, where at Padua, in the most ancient botanical garden in Europe, he made the acquaintance of Visiani, at that time one of the principal botanists in Italy. At Vienna he saw the learned Endlicher, the author of a classical "Genera Plantarum;" and at Munich, Von Martius, the renowned Brazilian traveler, the historian of the palms, and the earliest contributor to that stupendous work, the "Flora Brasiliensis," which bears his name; and here, too, was Zuccarini, the collaborator with Von Siebold in the "Flora Japonica." Geneva then, as at the present time, was a center of scientific activity; and there he made the personal acquaintance of the De Candolles, father and son, and worked in their unrivalled herbarium and library. He saw Schlechtendal at Halle; and at Berlin, Klotzsch, Kunth, and Ehrenberg,—familiar names in the annals of botanical science. Alphonse De Candolle and Sir Joseph Hooker alone are left of the brilliant group of distinguished naturalists who cordially welcomed the young American botanist in 1839."*

Dr. Gray also, while abroad, performed a great service for the University of Michigan, in superintending the selection of works for the nucleus of its library; and the University showed its appreciation of his judgment, and of the benefit to the institution, by honoring him, and itself, at its semi-centennial celebration the past summer, by conferring on him the degree of Doctor of Laws.

Again at home, and now well equipped for conquering difficulties about American species, he went at the Flora with new vigor. The first volume was completed by Torrey and Gray in 1840, and the second in February, 1843. In the interval between these dates, during the summer of 1841, Gray spent five to six weeks in a botanical excursion through the Valley of Virginia to the summits of the high mountains of North Carolina. A letter about the trip, addressed to Sir William J. Hooker, published in this Journal in 1842, first gives an account

* From a sketch of Dr. Gray by Prof. C. S. Sargent.

of the excursions into these regions by his predecessors, Bartram, Michaux, and John Fraser, of the last century, and John Lyon, Michaux the younger, Pursh, Nuttall, Curtis and others, of this, mentioning their discoveries, with critical remarks on the species they observed and on their distribution; and then he describes his own journey, adding notes on the plants met with by the way and in the mountains, commencing his observations at Harper's Ferry. His journey among the North Carolina Mountains included the ascent of the "Grandfather," 5897 feet in elevation, and the Roan Mountain, 6306 feet. This is one among a number of such excursions.

Another labor of this period was the revision of his "Elements of Botany," which, without much change of general method, he made a far more comprehensive and thorough treatise, and in 1842 issued, under the title of the "Botanical Text-book." Since then successive editions have appeared with large advances, as the science required. By the fifth edition, that of 1879, the subject had so expanded that it was divided, and the work made to include only Structural Botany, covering Morphology, Taxonomy and Phytography, leaving Physiological and Cryptogamic botany to other hands. The second volume, an exposition of Physiological Botany, appeared in 1885, from the pen of his colleague, Prof. G. L. Goodale. A third volume on Cryptogamic Botany is promised by another colleague, Prof. W. G. Farlow.

Gray never entered on duty at the Michigan University, it being impossible for him to carry on his publications so far away from the New York herbaria and botanical libraries. In 1842, he was invited by the Fellows of Harvard College to the Fisher Professorship of Natural History, recently founded on a bequest of Dr. Joshua Fisher. The duties of the professorship included the delivery of a course of lectures on Botany, and the direction of the small botanic garden which had been established in Cambridge in 1805, under the auspices and with the assistance of the Massachusetts Society for promoting Agriculture. Thomas Nuttall had charge of the garden from 1822 to 1828, and after that it was without a head until the appointment of Dr. Gray. The garden was still poor in funds, and had not even an herbarium to aid Gray in his botanical

studies. But he entered on the duties with zeal, conducted the required lectures in the most lucid and attractive manner, freely gave the use of his study to such students as wished to learn more of the science than they could acquire from the lectures, and gathered a vast herbarium. And all the time he carried on an enormous correspondence with promptness, and answered all social demands with unfailing courtesy, besides continuing his botanical investigations and writing books and memoirs. These duties continued until 1872, when he was relieved from that of teaching and the charge of the garden. In 1864, he made the offer to Harvard College of the herbarium and library which he had gathered, already very large, on the condition of their erecting a fire-proof building to contain them, which was accepted.

Botanical work was always in progress in some form. One of the very valuable parts of it consisted in his contributions to this Journal—which were continued, with scarcely any interruption, for the love of the science and of the men engaged in it. Every important work as it was issued was here noticed, with often critical remarks, or additional facts and illustrations, or modifications of opinions, that gave them great scientific value. And not the least instructive and attractive part were the biographical sketches of deceased botanists, European as well as American; for to him the world was all one, and all botanists were akin. He was sure to criticise what he believed to be wrong; but it was done so fairly, with so evident a desire for scientific accuracy, and in so kind a spirit, that offense was rarely given. A botanist of eminence says that "these notices form the best history of the botanical literature of the last fifty years, and of the progress and development of botanical science, that has been written."

The fortieth volume of this Journal (1841) contains an admirable example of his kindly method of reviewing an author that has faults, and of his critical study among great difficulties. It is a review of the botanical writings of Rafinesque, that enthusiastic naturalist, poet, etc., with reference, not to his faults, but to the value to be attached to his numerous genera and species and their recognition in American Botany. Throughout, there is a full appreciation of Rafinesque's saga-

city in many of his discriminations, a fair presentation of his scientific claims, of his love of nature and greater love of self, without a harsh word for his errors or egotism; and only a citing of a sentence here and there, or a fact, that enables Rafinesque to make his own presentations as to his species and genera, with a bare mention of his "twelve new species of thunder and lightning."

The publication of the second volume of the "Flora," in 1843, ended that work. The territory of the United States afterward took larger dimensions, and new fields were to be explored before a complete "Flora" could be published. Torrey was engaged on these studies until his death in 1873; and Gray also was publishing memoirs that were contributions to the subject. Gray's various memoirs include: descriptions of the collections made by Lindheimer, in western Texas (1843–48); by Fendler, in New Mexico (1846–7); by Wright, near the boundary of Texas and Mexico (1849 and 1851–2); by Thurber, along the United States and Mexican boundary (1851–2); the Botany of various Government surveys, and other Government reports, and a portion of the Botany of California. Other papers are distributed through the publications of learned societies, especially the American Academy of Arts and Sciences of Boston, which contains hundreds of pages of them, the Proceedings of the Philadelphia and California Academies, the Boston Society of Natural History, the Linnean Society of London, etc.

Further, the plants of the Wilkes Exploring Expedition, exclusive of the ferns and those from western North America, were early sent to him for description; and in 1854 appeared his Report, in quarto, accompanied by a folio atlas, containing a hundred plates.

Gray was three times over the Rocky Mountain region to the Pacific Coast. On the second trip he was accompanied by Sir Joseph Hooker; and an important paper on the "Vegetation of the Rocky Mountain Region" by them is published in the Reports of the Hayden Geological Survey for 1878. He was in Europe again in the years 1850–51. A note from Mrs. Gray says: "He went abroad especially for the plants of the Wilkes Expedition. After traveling in Switzerland (going up

the Rhine to Geneva, where he worked awhile in DeCandolle's herbarium), we went to Munich and saw Martius, and then back to England by Holland. On the first of October we went into Herefordshire to the country place of George Bentham, and spent two months there, Mr. Bentham going over with Dr. Gray the collection which had been sent out from America, a most generous piece of work." It was at this time, while at the Kew Gardens, near London, that he had the passing introduction to Darwin, alluded to in Darwin's first letter to him.*

In 1868, he crossed the ocean the fourth time, going in September and returning in November of the following year. He was hard at work over herbaria at Kew during both autumns; and worked also in Paris, Munich, Geneva, and elsewhere, but with more holiday than in any journey he took except the last. In this visit he was twice with Darwin, first in the autumn of 1868, and then in October, 1869.

After forty years of studying and discriminating among the older species of the continent and their representatives abroad, and of describing species from late discoveries, and of work at classification, with experimental work at Flora-making during the years 1838 to 1843, he was finally ready, in 1878, with the first part of a new North American "Flora," to which he gave the name of "Synoptical Flora of North America." This first part contained the Gamopetalæ after the Compositæ. A second part was published in 1884, comprising the Caprifoliaceæ to the Compositæ inclusive, or the ground of the second volume of Torrey and Gray's Flora; so that the middle half of the entire Flora is now completed. The two parts cover 974 closely printed pages. "They are masterpieces of clear and concise arrangement, and of compactness and beauty of method, and display great learning and analytical power." The progress of the science since the time of Michaux is well exhibited in the fact that while this author knew 193 species of Compositæ when he published his Flora, Gray, seventy-five years later, describes no less than 1636 species under 239 genera.

During these years, Dr. Gray added to the resources of the instructor in Botany by the publication of his "Manual," a

* Darwin's Life and Letters, p. 420.

descriptive work including all species growing east of the Mississippi and north of Tennessee and North Carolina. It was first issued in 1848, and its fifth and last edition in 1868. The "Elementary Lessons in Botany and Vegetable Physiology," also, was published first in 1868, as an accompaniment to the Manual, and has had its five editions at nearly the same dates. The first volume of another companion work to the Manual was issued in 1848—his "Genera Illustrata," containing descriptions of the genera of the United States Flora, with illustrations of great beauty by I. Sprague; and in 1849 a second volume was published, carrying the works nearly to the Leguminosæ; and here it stopped, on account, mainly, of the expense. His "Field, Forest and Garden Botany," a useful flora for schools, came out in 1868; and the charming smaller volumes "How Plants Grow," and "How Plants Behave," respectively in 1858 and 1875. The latter was prompted by Darwin's works on Insectivorous Plants, the Orchids, and Dimorphism, and both are well adapted to the young student and all uninitiated readers.*

Besides the subjects of Gray's investigations already mentioned, two others of a wider philosophical character interested him deeply: one, in which he was pioneer, the other, the Origin of Species, after Darwin.

The first of these subjects was the Geographical Distribution of Plants, and particularly the species of the Northern United States both within and beyond the bounds of the continent, and the bearings of the facts on variation and origin.

His first paper on the subject is contained in volumes xxii and xxiii of this Journal, the numbers for September, 1856, and January and May, 1857. It was written partly in compliance with the request of "an esteemed correspondent" for a list of American alpine plants, who, as now appears, was Darwin. Darwin's Life contains, on page 420, the letter, and shows that its date was April 25, 1855; and, also, a second letter of June 8, 1855, which opens thus: "I thank you cordially for your remarkably kind letter of the 22d ult., and for the extremely pleasant and obliging manner in which you have taken my

* A list of Dr. Gray's publications will be given in another number of this Journal.

rather troublesome questions. I can hardly tell you how much your list of alpine plants has interested me." And then Darwin puts more questions to his genial correspondent.

The long paper, modestly entitled "Statistics of the Flora of the United States," contains numerous tables, comparing as regards plants the Northern United States with Europe on one side, and Asia and Japan on the other; the eastern part of the country with the western, and with the adjoining continents in the north-temperate zone; the plants of alpine and subalpine regions in the Northern United States, and their distribution southward, and eastward and westward over the other continents; the distribution of species common to this country and Europe, as to size of orders and genera; also, as regards related and representative species, and the same for Eastern and Western America; lists of species of widely sundered habitation; with numerous other points, and abundant explanatory remarks; making thus a thorough philosophical digest of the subject of geographical distribution, having all the completeness as respects the northern United States that the existing state of the science admitted of. He closes with a general review of the characteristics of the North American flora.

In the course of the pages, he advocates the idea of a single area of origin for a species, with dispersion at an epoch more or less ancient, to account for distribution; sustains Darwin's "surmise" as to the species of large genera having a greater geographical area than those of small genera; observes that a large percentage of the extra-European types of Eastern America are shared with Eastern Asia; and finds, "that curiously enough, eleven, or one-third of our strictly alpine species common to Europe—all but one of them arctic in the Old World—are not known to cross the Arctic circle on this continent; so that it seems almost certain that the interchange of alpine species between us and Europe must have taken place in the direction of Newfoundland, Labrador and Greenland, rather than through the polar regions" (xxiii, 73).

Two years later, in 1859, Dr. Gray had studied a collection of plants from Japan (alluded to in the former paper, xxiii, 369, as in hand), which had been collected by Mr. Charles Wright; and his memoir on the subject, read that year before

the American Academy of Arts and Sciences, closes with a sequel to the subject of Geographical Distribution, bringing out conclusions of still higher interest. He starts off with the then new announcement and its evidence, that among the plants of Japan, more species are represented in Europe than over the nearer land, western North America; more in eastern North America than in either of the other two regions; and adds, that hence, there has been a peculiar intermingling of the eastern American and eastern Asia floras, which demands explanation. The explanation he finds in the idea of migrations to and from the arctic regions, determined in part, at least, by the climate of the preglacial, glacial and postglacial eras; and that the alpine plants of the summits of the White Mountains, Adirondacks, Black Mountains and Alleghanies, are species left by the retreating glacier.

Dr. Gray returned to this subject in his presidential address, in 1872, before the American Association for the Advancement of Science,* and, owing to th progress that had been made in the paleontology of the continent, the arctic portion as well as the more southern, and developments elsewhere also, he was enabled to trace out the courses of the migrations of plants, the Sequoias or Redwoods and many other kinds, by positive facts with regard to the arctic and more southern floras; and showed that the distribution southward into the western United States, into eastern Europe or western Eurasia, and into Japan and Asia or eastern Eurasia, was not only dependent, as he had before put forth, on change in continental climates, but also that the particular direction southward was determined to a large extent by fitness of climate as to heat and dryness. The surprising revelations are now so generally known that this brief reference to them is all that is here needed.

Gray's comprehensive knowledge of the plants of the world, of their distribution, and specifically of the relations of North American species, genera and orders to those of the other continents, and the precision of his knowledge, enabled him to be of much service to Darwin in the preparation of the first edition of the Origin of Species, and afterward, also, in the elab-

* This Journal, III, iv, 282, 1872.

oration of Darwin's other publications. His mind was not very strongly bound to opinions about species, partly because of his natural openness to facts, his conclusions seeming always to have only a reasonable prominence in his philosophical mind, rarely enough to exclude the free entrance of the new, whatever the source, and to a considerable extent from the difficulties he had experienced in defining species and genera amidst the wide diversities and approximate blendings which variation had introduced.

Darwin first mentioned to Gray his view that "species arise like varieties, with *much* extinction," in a letter to Gray of July 20th, 1856.* At this time all men of science with a rare exception believed in the permanence of species. J. D. Hooker's Flora Indica of 1855 "assumes that species are *distinct* creations."† Prof. Huxley, in his history of the reception of Darwinian ideas, says, with the perfect fairness that always has characterized him, that "within the ranks of the biologists, at that time [1851–8], I met with nobody [and he here includes himself] except Dr. Grant, of University College, who had a word to say for evolution; and his advocacy was not calculated to advance the cause. Outside of these ranks, the only person known to me whose knowledge and capacity compelled respect, and who was, at the same time, a thoroughgoing evolutionist, was Herbert Spencer. . . . But even my friend's rare dialectic skill and copiousness of apt illustration could not drive me from my agnostic position." Lyell, he shows, was leaning that way, but not himself. So it was in 1857, and in 1858 up to the publication of Darwin's and Wallace's papers of that year.‡

Gray therefore knew of Darwin's views before the biologists of Britain, unless we except Lyell and J. D. Hooker. Darwin acknowledged Gray's "remarkably kind letter" on the 5th of September, 1857,§ and is prompted by his "extraordinary kindness," and, evidently, by his assurances, that he had no objections to facts from any source, had great interest in the subject, and only saw some "grave difficulties" against his doctrine, to

* Darwin's Life and Letters, p. 437.

† Gray's review, this Journal, xxi, 135, Jan., 1856.

‡ Darwin's Life and Letters, chapter xiv of vol. i, by Prof. Huxley.

§ Ibid, p. 477.

explain to Dr. Gray with detail, under six heads, the prominent facts and arguments in the theory of "Natural Selection," which he says is the "title of his book." This letter is the first exposition that Darwin had made of his theory, and hence it has proved to have great documentary value.

A letter which the writer received from Gray in the interval between Darwin's two letters, dated December 13, 1856, shows well the state of his mind at that time. He says: "On the subject of species, their nature, distribution, what system in Natural History is, etc., etc., certain inferences are slowly settling themselves in my mind or taking shape; but, on some of the most vexed questions, I have as yet no *opinion* whatever, and no very strong *bias*, thanks partly to the fact that I can think of and investigate such matters only now and then, and in a very desultory way."*

In a letter of a year later, subsequent in date to Darwin's letter, Gray wrote me with reference to my paper on "Species" read at the meeting of the American Association in August, 1857—which paper may be taken, perhaps, as a culmination of the past, just as the new future was to make its appearance—pointing out to me the fatal objection to my argument.

His words (dated November 7th) are worth quoting: "Taking the *cue* of species, if I may so say, from the *inorganic*, you develop the subject to great advantage for your view, and all you say must have great weight in 'reasoning from the general.' But in reasoning from *inorganic species* to *organic species*, and in making it tell where you want it, and *for what* you want it to tell, you must be sure that you are using the word *species* in the same sense in the two; that the one is really the equivalent of the other. That is what I am not yet convinced of; and so to me the argument comes only with the force of an *analogy*, whereas I suppose you want it to come as demonstration. Very likely you could convince me that there is no fallacy in reasoning from the one to the other to the extent you do. But all

*Gray has some important observations on the bearing of hybridization on variation, in a review of Hooker's Flora Indica in the number of this Journal for January, 1856, (xxi, 134).

my experience makes me cautious and slow about building too much on analogies; and until I see further and clearer I must continue to think there is an essential difference between *kinds of animals or plants* and *kinds of matter.*

"How far we may safely reason from the one to the other is the question. If we may do so even as far as you do, might not Agassiz (at least plausibly) say that as the *species Iron* was created in a vast number of individuals over the whole earth, so the presumption is that any given species of plants or animals was originated in as many individuals as there are now, and over as wide an area; the human species under as great diversities as it now has, barring historical intermixture; thus reducing the question between you to insignificance? because, then, the question whether men are of one or of several species would no longer be a question, or of much consequence. You may answer him from *another starting point*, no doubt; but he may still insist that it is a legitimate carrying out of your principle."

In the same letter Gray prophesies as follows,—from actual knowledge, it now appears: "You may be sure that before long there must be one more resurrection of *the development theory* in a new form, obviating many of the arguments against it, and presenting a more respectable and more formidable appearance than it ever has before."

The Origin of Species was out in November, 1859. Gray received an early copy of it from Darwin, and therefore his very valuable review was ready for this Journal early in 1860.*

With regard to the sufficiency of the argument brought forward in Darwin's work, Gray says that "To account upon these principles for the gradual elimination and segregation of nearly allied forms—such as varieties, sub-species and closely related or representative species—and also for their geographical association and present range, is comparatively easy, is apparently within the bounds of possibility, and even of probability." But as to the formation of genera, families, orders and classes by natural selection, Gray simply states Darwin's arguments on the subject, and some objections on a few weak points, without expressing further his own views. He

* It occupies 32 pages in the March number, vol. xxix, pp. 153 to 184.

concludes with some remarks on the religious bearing of a theory that refers creation to natural law and declares rightly, in accordance with his firm faith to the end, that "Natural law is the human conception of continued and orderly Divine action."

Darwin, in a letter to Gray written during the following summer, having in view Gray's article in this Journal, and another discussion of his published in the Proceedings of the American Academy, says, "I declare that you know my book as well as I do myself, and bring to the question new lines of illustration and argument in a manner which excites my astonishment and almost my envy." "As Hooker lately said in a note to me, you are, more than *any one* else, the thorough master of the subject."

Gray's "Darwiniana," published in 1876, is composed of a number of his essays and reviews, from this Journal, the "Nation" and the "Atlantic Monthly," together with a closing chapter, written for the volume, entitled "Evolutionary Teleology." The last chapter brings out Gray's adherence to the doctrine of Natural Selection, and also his divergence from true Darwinism. These divergences are thus expressed:

"We are more and more convinced that variation, and therefore the ground of adaptation, is not a product of, but a response to, the action of the environment. Variations, in other words the differences between individual plants and animals, however originated, are evidently not from without, but from within; not physical, but physiological." And elsewhere he has said that the variation in a species is apt to take place in particular directions and make linear ranges of varieties, as often exemplified among plants; which accords with the preceding conclusion, pp. 386.

Again, speaking of the forms of Orchids and their connection with, and relation to, insect fertilization, he says: "We really believe that these exquisite adaptations have come to pass in the course of nature, and under Natural Selection, but not that Natural Selection alone explains or in a just sense originates them. Or, rather, if this term is to stand for sufficient cause and rational explanation, it must denote or include that inscrutable something which produces, as well as that which results in the survival of, 'the fittest,'" p. 388.

Both of these doctrines are anti-Darwinian, though not at variance with Natural Selection. They take away what has often been urged against Darwinism: the idea that the environment under natural selection dominates in the determination of the direction of variation, and hence that evolution comes chiefly through external conditions; and substitutes the idea that the environment works under organic control through Natural Selection. One view implies that the environment influence is superior to organic law in the process; the other, that organic law is superior to the environment. Moreover, Gray's last sentence expresses the opinion that Darwin's Natural Selection cannot produce the "survival of the fittest," though "survival of the fittest" is the *result* brought about. There is an "inscrutable something" that "produces." The writer would go a little farther and say that the "survival of the fittest," under "natural selection," is *survival*, not the *production* of "the fittest;" but this substitute I have reason to believe that Gray would not accept.

Further, Gray was a theistic Darwinian, as abundantly shown in his Darwiniana, and alike also in his "Natural Science and Religion." Here is his creed in his own words, as published in the Preface to the Darwiniana: "I am scientifically and in my own fashion a Darwinian, philosophically, a convinced theist, and religiously, an accepter of the 'creed commonly called the Nicene,' as the exponent of the Christian faith."

Gray's various literary or less scientific papers, contributions mostly to the "North American Review," "Nation," and the "Atlantic Monthly," always show the clear thinker, the graceful writer and the well-stored head, whatever the topic; and when it is scientific, his method of popularizing and illustrating his views is of the most attractive kind. His last contribution to the "Nation" was a long characteristic notice of Darwin's Life and Letters, in November, showing no waning in his faculties; on the contrary, there is manifest the same clear-headed, judicial and sprightly reviewer, as honest as ever in his opinions and in his modesty amid Darwin's profuse (he says effusive) commendations.

The last visit to Europe was made during the past year. He went with the intention of doing but little of his herbarium work, and, finding pleasure among friends, old and new. Mrs. Gray, as usual, was with him. It proved to be a triumphal time to the modest botanist; for he received the honor of doctorate from each of the great Universities of Britain, that of Oxford, of Cambridge and of Edinburgh. He returned in October, in excellent spirits and health—an apparent promise of some years more of work. He was soon again occupied with his "Flora," the completion of which was the earnest desire of all botanists. Yet while wishing to see its last page himself, his anxiety about it had lessened in later years, because aware that his colleague in charge of the Herbarium, Dr. Sereno Watson—one of the students that he had gathered about him—was capable of taking up the lines whenever he should lay them down.

Gray's standing among philosophers abroad is manifested in his recent reception in Great Britain. It is further shown in his having been elected an honorary member of all the principal Academies or Societies of Science in Europe, including the Royal Society of London and the Institute of France. He was President of the Association for the Advancement of Science in the year 1871, and has been one of the Regents of the Smithsonian Institution since 1874; and for ten years, from 1863 to 1873, he was President of the American Academy of Arts and Sciences. In 1884 his portrait in bronze, made by St. Gaudens, was presented to Harvard College.

One of the most gratifying testimonials from his fellows in science was received on his seventy-fifth birthday. To his surprise there came greetings or notes of congratulations from every American botanist, old and young, and, along with the notes, a silver vase embossed with figures of the plants more particularly identified with his name or studies. It was delightful to witness, says one of his associates, his child-like pleasure as he received the gift. Among the letters were some from friends who were not botanists. The following lines were from Mr. Lowell:

JUST FATE : prolong his life, well spent,
Whose indefatigable hours
Have been as gaily innocent
And fragrant as his flowers.

The vase is about eleven inches high exclusive of the ebony pedestal. The pedestal is surrounded by a hoop of hammered silver on which is the inscription

1810 November eighteenth 1885
ASA GRAY
In token of the universal esteem
of American Botanists

Among the flowers, in raised figures about the vase, the place of honor on one side is held by *Grayia polygaloides*, and on the other by *Shortia galacifolia*. On the Grayia side, the prominent plants are *Aquilegia Canadensis*, *Centaurea Americana*, *Jeffersonia diphylla*, *Rudbeckia speciosa* and *Mitchella repens;* and on the Shortia side, there are *Lilium Grayi*, *Aster Bigelovii*, *Solidago serotina* and *Epigæa repens*. The lower part of the handles runs into a cluster of Dionæa leaves, which clasps the body of the vase, and their upper part is covered with *Notholæna Grayi*. *Adlumia cirrhosa* trails over the whole back-ground, and here and there its leaves and flowers crop out. The greetings, in the form of cards and letters, that had been sent by the givers of the vase, were placed on a simple but elegant silver plate, which had within the engraved inscription: BEARING THE GREETINGS OF ONE HUNDRED AND EIGHTY BOTANISTS OF NORTH AMERICA TO ASA GRAY, ON HIS SEVENTY-FIFTH BIRTHDAY, NOVEMBER 18TH, 1885.*

Botanists have, as their common object of interest, that part of Nature which seems by its free gift of beauty and fragrance (without a trace of self, the dominating element in the animal) fully to reciprocate affection; and there is hence a reason for that feeling of fraternity which such a gift so beautifully expresses, independently of the tribute in it to the botanist of botanists. Plants seem thus to select from among enquiring minds those which are to be their investigators, or the botanists.

* This description of the vase is from the "Botanical Gazette" of December, 1885, which contains also good figures of the vase.

It is a case of Natural Selection. But Dr. Gray was more to botanists than a friend and leader. He was the "Beloved Gray"—the object of their admiration and devotion on account of his goodness, his high principle, his frank independence, his unfailing cordiality, and the clearness of his intellectual vision, like that of a seer. He stands before the world as a lofty example of the Christian philosopher.

Dr. Gray was married, in 1848, to the daughter of the late eminent lawyer of Boston, Charles G. Loring. His excellent and accomplished wife, who survives him, was in full sympathy with him in all his pursuits and pleasures, a bright, cheerful and helpful companion, at home and in his travels abroad.

In a letter to the writer in 1886, Gray says:

—— I have had a week in old Oneida, which still looks natural. I am grinding away at the Flora, and shall probably be found so doing when I am called for. Very well: I have a most comfortable and happy old age.

Wishing you the same,

Yours ever, A. Gray.

November last, the month after his return from Europe, he put aside his nearly completed revision of the "Vitaceæ, or Grapevines of North America" to write his last words about Darwin in the review of Darwin's Life and Letters, and to prepare his usual annual Necrology for this Journal. The latter manuscript lay unfinished on his table, when, on the 27th of the month, a paralytic stroke put an end to work, with every prospect then that his name also would have to be added to the list of 1887. He lingered until the 30th of January, without a return, at any time, of his powers of speech, and toward evening of that day passed quietly away.

Asa Gray's remains lie buried in the Mt. Auburn Cemetery. American botanical science, wrought out so largely in its details, its system, and its philosophical relations, by his labors, is his monument.

J. D. D.

ART. XVII.—*Calibration of an Electrometer;* by D. W. SHEA.

THE mathematical theory* of the quadrant electrometer leads to the general formula:

$$\Theta = \alpha\,(A-B)\,(C-\tfrac{1}{2}\,(A+B),$$

in which θ represents the moment of the couple which turns the needle, A, B, C, the potentials of the two pairs of quadrants and of the needle respectively, and α is a constant which defines the sensibility of the instrument. The deflection of the needle is proportional to the moment θ. Hence, if α is a constant† as the theory supposes, the deflection of the needle should be proportional to the product

$$(A-B)\,(C-\tfrac{1}{2}\,(A+B),$$

and the curve of calibration obtained in any given method of setting up the electrometer should have a perfectly definite and constant form. But in the various forms of the quadrant electrometer, and in the different methods of setting up the same instrument, the curves of calibration obtained correspond in a very irregular manner with the curves given by theory.‡

Some observations with an electrometer of the Mascart form, which show variations apparently due to change in the sensibility with variation in the temperature,§ are given in the following pages. It is possible that they may be of interest to those who use this form of electrometer.

The results here given were obtained with the electrometer set up in the following manner:

The needle was suspended by a bifilar suspension consisting of a single fiber of cocoon silk, the ends of which were fastened to the drum and the loop to the hook on the upper end of the rod carrying the needle. The two parts of the fiber were separated as widely as the construction of the instrument admits of. The needle was charged by a water-battery. The positive pole of the battery was attached to the electrode connecting with the inner coating of the Leyden jar, and the negative pole and the electrometer case were to ground. The water-battery was made up of four hundred cells of zinc-copper elements, arranged in boxes of eighty cells each. The difference of poten-

* Maxwell, Electricity and Magnetism, vol. i, p. 311.
† Hopkinson, Phil. Mag., V, xix, p. 297.
‡ Mouton, Journal de Physique, vi, p. 13.
Benoit, Journal de Physique, vi, p. 118.
Boltzmann, Pogg. Ann., bd. cli, p. 487.
Hallwachs, Wiedemann's Ann. der Phys. und Chem., xxix, p. 35.
§ Hallwachs, ibid., p. 41.

tial between the positive pole of any one of these boxes of cells and the ground, with the negative pole to ground, was about forty volts.

In making the calibration, a battery of small gravity cells was used, with circuit closed through an external resistance of ten thousand ohms. One and the same end of the set of resistance coils was to ground in all observations. Points on the box of coils such that one, two, three, etc., thousand ohms were included between them and the point to ground were successively connected to one pair of quadrants, while the other pair of quadrants was to ground, and the quadrant connections were alternated in order to get readings on the right and left of the zero, which was placed at the middle point of the scale. The needle was charged by one, two, three, etc., boxes of cells successively, and the number of cells in the gravity battery was decreased, as the charge of the needle was increased, so as to keep the difference of potential between the ends of the set of resistance coils such that the spot of light always remained on the scale.

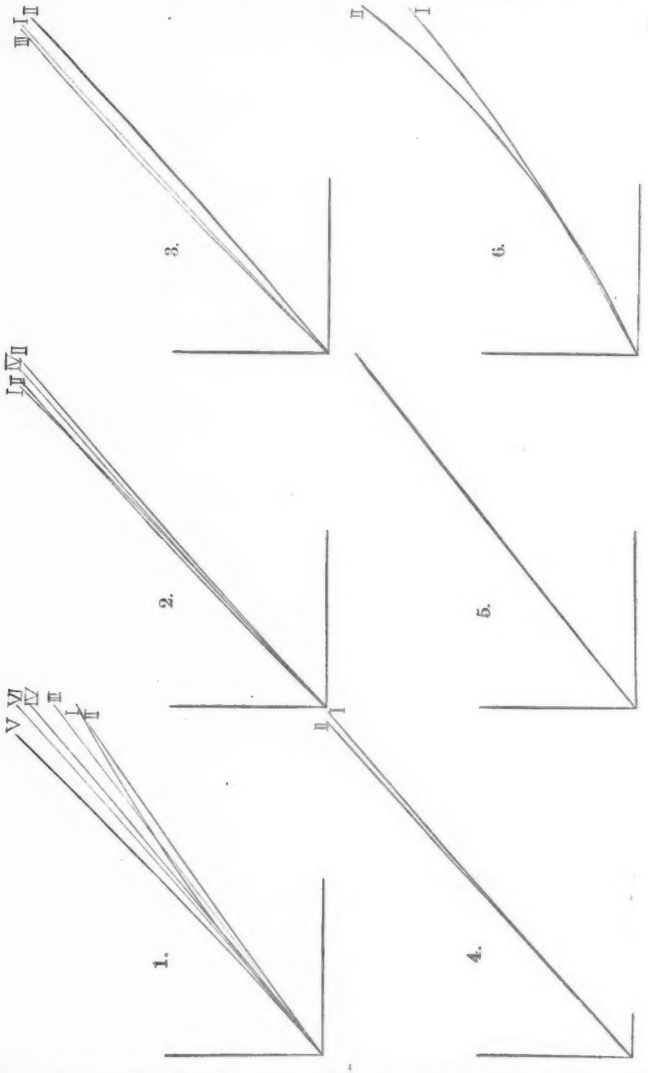
It was found that the form of the curve for a given charge of the needle did not long remain constant, and that even the direction of curvature changed. The change in the form of the curve was greatest when the charge of the needle was smallest, and it was not until the whole water-battery of four hundred cells was employed that a curve was obtained which changed so little as to admit of accurate work. The change in the curves was most rapid when the temperature of the room was changing rapidly between certain limits. Beyond these limits there was little change in the curves. But for any given temperature between the limits the form of the curve was not constant, even though the temperature of the room had been so constant for several hours that all parts of the electrometer could reasonably be supposed to have the temperature of the room.

The changes in the form of the curves for various charges of the needle were followed through the range of temperature attainable, at the time, in the room where the electrometer was set up. The following tables will serve to show these changes.

In all the observations the scale was at a distance of 126^{cm} from the mirror.

The curves shown in the plate were plotted by taking the potentials of the quadrants as abscissas and the deflections of the needle in degrees as ordinates. Fig. 1 shows curves when charge of needle was forty volts; fig. 2, when charge was eighty volts; fig. 3, when charge was one hundred and twenty

volts; fig. 4, when charge was one hundred and sixty volts; fig. 5, when charge was two hundred volts; fig. 6, I, when



charge was twenty volts, and II, when charge was ten volts. The Roman numerals in the figures refer to the tables.

Charge of Needle, 40 volts.

I.

TEMPERATURE, 6° C.

Resistance between point to ground and point to pair quadrants in ohms.	Charge of quadrants in volts.	Scale readings in cm. Right.	Scale readings in cm. Left.	Mean of two scale readings.	Deflection of needle in degrees.
1000·	2·5	2·13	2·17	2·15	0° 29′·5
2000·	5·0	4·30	4·20	4·25	0 58
3000·	7·5	6·28	6·20	6·24	1 25
5000·	12·5	10·07	9·85	9·96	2 15·5
7000·	17·5	13·46	13·34	13·40	3 2
8000·	20·0	15·05	15·00	15·02	3 24
9000·	22·5	16·49	16·41	16·45	3 43
10000·	25·0	17·92	17·94	17·93	4 2·5

II.

TEMPERATURE, 8° C.

1000·	2·5	1·93	1·92	1·925	0 26
2000·	5·0	3·81	3·79	3·80	0 52
3000·	7·5	5·64	5·61	5·625	1 17
5000·	12·5	9·17	9·12	9·145	2 4
7000·	17·5	12·85	12·84	12·845	2 54
8000·	20·0	14·60	14·68	14·64	3 19
9000·	22·5	16·29	16·23	16·26	3 40·5
10000·	25·0	17·79	17·78	17·785	4 1

III.

TEMPERATURE, 11° C.

1000·	2·5	2·03	2·04	2·035	0° 28′
2000·	5·0	4·03	4·03	4·03	0 55
3000·	7·5	5·94	6·02	5·98	1 22·5
5000·	12·5	9·95	9·99	9·97	2 16
7000·	17·5	13·70	13·76	13·73	3 6·5
8000·	20·0	15·76	15·84	15·80	3 34·5
9000·	22·5	17·89	17·91	17·90	4 2
10000·	25·0	19·81	19·87	19·84	4 28

IV.

TEMPERATURE, 12° C.

1000·	2·5	1·91	1·89	1·90	0 26
2000·	5·0	3·85	3·87	3·86	0 52·5
3000·	7·5	5·90	5·95	5·92	1 20·5
5000·	12·5	10·08	10·12	10·10	2 17·5
7000·	17·5	14·30	14·33	14·315	3 14·5
8000·	20·0	16·50	16·54	16·52	3 44
9000·	22·5	18·71	18·80	18·75	4 13·5
10000·	25·0	20·79	20·82	20·805	4 47

V.

TEMPERATURE, 14° C.

Resistance between point on coils to the ground and point to quadrants in ohms.	Charge of the quadrants in volts.	Scale readings in cm. Right.	Scale readings in cm. Left.	Mean of the two scale readings.	Deflection of needle in degrees.
1000·	2·5	2·12	2·14	2·13	0° 29′
2000·	5·0	4·29	4·29	4·29	0 58·5
3000·	7·5	6·58	6·58	6·58	1 29·5
5000·	12·5	11·30	11·32	11·31	2 34
7000·	17·5	16·41	16·44	16·425	3 43
8000·	20·0	19·02	19·06	19·04	4 18
9000·	22·5	21·86	21·97	21·915	4 56

VI.

TEMPERATURE, 16° C.

1000·	2·5	1·93	1·89	1·91	0 26
2000·	5·0	3·90	3·94	3·92	0 53
3000·	7·5	6·00	6·03	6·015	1 22
5000·	12·5	10·37	10·37	10·37	2 20·5
7000·	17·5	15·15	15·18	15·17	3 26
8000.	20·0	17·64	17·71	17·68	3 59·5
9000·	22·5	19·85	19·88	19·865	4 28·5
10000·	25·0	22·15	22·24	22·20	5 0·0

Charge of Needle, 80 *volts.*

I.

TEMPERATURE, 6°·5 C.

1000·	1·3	2·35	2·35	2·35	0° 32′
2000·	2·6	4·72	4 69	4·705	1 4
3000·	3·9	7·15	7·13	7·14	1 37
5000·	6·5	12·01	12·04	12·025	2 43·5
7000·	9·1	16·94	16·95	16·945	3 49·5
8000	10·4	19·32	19·30	19·31	4 21·5
9000·	11·7	21·72	21·72	21·72	4 53·5

II.

TEMPERATURE, 9° C.

1000·	1·3	2·26	2·26	2·26	0 31
2000·	2·6	4·57	4·57	4·57	1 2
3000·	3·9	6·83	4·75	6·79	1 32
5000·	6·5	11·34	11·34	11·34	2 34
7000·	9·1	16·13	16·14	16·135	3 38·5
8000·	10·4	18·40	18·35	18·375	4 8·5
9000·	11·7	20·59	20·53	20·56	4 37

III.

TEMPERATURE, 12° C.

1000·	1·3	2·47	2·46	2·465	0° 33′·5
2000·	2·6	4·90	4·85	4·875	1 6·5
3000·	3·9	7·31	7·26	7·285	1 39·5
5000·	6·5	12·12	11·95	12·035	2 44
7000·	9·1	16·74	16·73	16·735	3 46·5
8000·	10·4	19·08	19·07	19·075	4 18
9000·	11·7	21·43	21·36	21·395	4 49

IV.

TEMPERATURE, 17° C.

Resistance between point on coils to ground and point to quadrants in ohms.	Charge of the quadrants in volts.	Scale readings in cm. Right.	Scale readings in cm. Left.	Mean of the two scale readings.	Deflection of the needle in degrees.
1000·	1·3	2·60	2·59	2·595	0 35·5
2000·	2·6	5·05	4·97	5·01	1 8
3000·	3·9·	7·60	7·51	7·555	1 43
5000·	6·5	12·55	12.41	12·48	2 47
7000.	9·1	17·35	17·23	17·29	3 54·5
8000·	10·4	19·50	19·57	19·535	4 24·5
9000·	11·7	21·85	21·78	21·815	4 54·5

Charge of Needle, 120 *volts.*

I.

TEMPERATURE 8° C.

1000·	0·7	2·29	2·30	2·295	0°31′
2000·	1·4	4·62	4·61	4·615	1 3
3000·	2·1	7·04	6·99	7·015	1 35·5
5000·	3·5	11·77	11·82	11·795	2 40·5
7000·	4·9	16·47	16·41	16·44	3 43
8000·	5·6	18·84	18·79	18·815	4 14·5
9000·	6·3	21·22	21·20	21·21	4 46·5

II.

TEMPERATURE 12° C.

1000·	0·7	2·23	2·24	2·235	0°30′·5
2000·	1·4	4·37	4·32	4·345	0 59
3000·	2·1	6·56	6·49	6·525	1 27·5
5000·	3·5	10·99	11·01	11·00	2 27
7000·	4·9	15·52	15·56	15·54	3 31
8000·	5·6	17·99	18·00	17·995	4 3·5
9000·	6·3	20·20	20·20	20·20	4 34

III.

TEMPERATURE 17° C.

1000·	0·7	2·43	2·44	2·435	0°33′
2000·	1·4	4·86	4·87	4·865	1 6
3000·	2·1	7·25	7·26	7·255	1 39
5000·	3·5	12·02	12·01	12·015	2 44
7000·	4·9	16·74	16·76	16·75	3 47
8000·	5·6	19·03	19·12	19·075	4 19·5
9000·	6·3	21·51	21·53	21·52	4 51

Charge of Needle, 160 *volts.*

I.

TEMPERATURE 7° C.

1000·	0·55	2·28	2·28	2·28	0°31′
2000·	1·10	4·53	4·52	4·525	1 1·5
3000·	1·65	6·80	6·79	6·795	1 32·5
5000·	2·75	11·28	11·21	11·245	2 33
7000·	3·85	15·78	15·67	15·725	3 33·5
8000·	4·40	18·00	17·93	17·965	4 4
9000·	4·95	20·30	20·20	20·25	4 34·5

II.

TEMPERATURE 18° C.

Resistance between point on coils to ground and point to quadrants in degrees.	Charge of quadrants in volts.	Scale readings in cm.		Mean of the two scale readings.	Deflection of the needle in degrees.
		Right.	Left.		
1000·	0·55	2·30	2·33	2·315	0°31′·5
2000·	1·10	4·61	4·65	4·63	1 3
3000·	1·65	6·87	6·97	6·92	1 34
5000·	2·75	11·41	11·61	11·51	2 36·5
7000·	3·85	14·98	15·20	15·09	3 25
8000·	4·40	18·21	18·49	18·35	4 8
9000·	4·95	20·50	20·73	20·615	4 57·5

Charge of Needle, 200 volts.

TEMPERATURE 17° C.

1000·	0·46	2·00	1·99	1·995	0°27′
2000·	0·92	3·99	3·99	3·99	0 54
3000·	1·38	5·99	5·96	5·975	1 22·5
5000·	2·30	9·98	9·94	9·96	2 15·5
7000·	3·22	14·00	13·96	13·98	3 10
8000·	3·68	16·02	15·96	15·99	3 37
9000·	4·14	18·00	17·96	17·98	4 3·5
10000·	4·60	20·00	19·90	19·95	4 30

It was found that the curve of calibration, when the charge of the needle was 200 volts, was practically constant for a range of temperature from 6° to 25° C.

The curves of calibration for the cases where the needle has charge of 10 and 20 volts were not examined very carefully, but it was observed that the variation was much greater than in the other cases. The following tables will serve to show the form of the curves for these cases:

Charge of Needle, 10 volts.

TEMPERATURE 18° C.

Resistance between point to ground and point to quadrants in ohms.	Charge of quadrants in volts.	Scale readings in cm.		Mean of two scale readings.	Deflection of needle in degrees.
		Right.	Left.		
1000·	4·3	1·02	1·04	1·03	0°15′
2000·	9·6	2·24	2·24	2·24	0 30·5
3000·	12·9	3·69	3·71	3·70	0 51
5000·	21·5	7·41	7·39	7·40	1 41
7000·	30·1	11·83	11·81	11·82	2 41
8000·	34·4	14·25	14·27	14·26	3 13·5
9000·	38·7	17·21	17·16	17·185	3 53
10000·	43·0	20·25	20·26	20·255	4 34·5

Charge of Needle, 20 volts.

TEMPERATURE 17° C.

Resistance between point to ground and point to the quadrants in ohms.	Charge of the quadrants in volts.	Scale readings in cm.		Mean of two scale readings.	Deflection of needle in degrees.
		Right.	Left.		
1000·	3·2	1·19	1·22	1·205	0°16′·5
2000·	6·4	2·55	2·55	2·55	0 35
3000·	9·6	3·95	3·93	3·94	0 53
5000·	16·0	7·07	7·04	7·055	1 36
7000·	22·4	10·50	10·53	10·515	2 23·5
8000·	25·6	12·44	12·45	12·445	2 46·5
9000·	28·8	14·42	14·41	14·415	3 16
10000·	32·0	16·61	16·63	16·62	3 44·5

In making the calibrations, examinations for leakage were frequently made by charging the quadrants and breaking their connection with the battery circuit. The constancy of the gravity and water batteries was determined by means of a constant cell, devised by Dr. Willson.* The electro-motive force of this cell, which was taken as the standard in these observations, is 1·085 to 1·088 volts. This variation is so small that it is not observable with the electrometer, which is not capable of measuring less than ·01 of a volt, when set up in the manner described, and the needle having a charge of 200 volts.

It will be noticed that the variation in the sensibility decreases as the charge of the needle becomes great relatively to that of the quadrants. The mathematical theory supposes that the charge of the needle is high when compared with that of the quadrants, but it gives no idea of what the order of the charges should be. These observations seem to show that in making use of an electrometer for electrical measurements, we should ascertain by experiment what charge the needle must have, in order that the sensibility may remain constant for the range of charges to be given the quadrants.

Much trouble was experienced at first through the electrometer being set up in a room in which several students were at work upon various experiments in electricity. This trouble seemed to be due to induction effects on the quadrants, which the electrometer case did not very completely shield, for on enclosing the electrometer in a box coated with tin-foil, and put into connection with the ground, the trouble was removed. After removing another difficulty, i. e., leakage, due to use of glass rods in the construction of a commutator, by substituting paraffine for the glass, it was found that the electrical zero suffered a displacement to the side to which the spot of light was deflected.† This displacement increased with

* Über Daniell'sche Normal-Elemente, Inaugural Dissertation von Robert W. Willson, aus Cambridge, U. S. Würzburg, 1886. Pamphlet.

† Thomas Gray, Phil. Mag., V, vol. xxiii, p. 46.

the magnitude of the deflection, and was as great as one centimeter, at the end of two or three minutes, for a deflection of twenty centimeters. The suspending fiber had been in the instrument for some time, inquiry showed that it was drawn from floss silk.* On substituting a fiber drawn from cocoon silk which had been well washed, no displacement of the zero was observed except where the room had been kept at about 0° C. for several hours. Some trouble was experienced from sudden movements of the needle, apparently caused by the working of a dynamo, from which wires extended through the various parts of the building in close proximity to the pipes for gas and water, the pipes being made use of as ground connections for the electrometer and batteries. These deflections of the needle were most marked in the cold, dry weather of winter; from this it seems probable that the pipes did not serve as very good ground connections at the time and under the circumstances.

Jefferson Physical Laboratory, Dec. 5th, 1887.

Art. XVIII.—*On the so-called Northford, Maine, Meteorite;* by F. C. Robinson.

Various cabinets in this state and doubtless elsewhere contain specimens of a black rock showing signs of external fusion, labeled "Meteorite which fell in Northport, Maine." A specimen recently received from Mr. W. H. Sargent, of Brewer, Maine, has been analyzed in my laboratory by Mr. Charles Fish, with the following results:

Fe	Al	Cu	Mg	Co	SiO_2	S	P	Mn	
43·37	4·19	0·88	2·05	0·25	27·68	1·10	0·03	*tr*	= 79·55

The Mg, Al and most of the Fe were evidently combined as silicates. The rest of the Fe was present as sulphide and oxide, and the copper as sulphide. Calculating them as such the analysis comes up to 98·36 per cent omitting the small amount of P, Co, Mn. The piece I have and others I have seen are nearly or quite black in color, and seem to have been broken from a nearly spherical mass of about 1½ or 2 feet in diameter, whose outer surface was fused. Sections under the microscope closely resemble those made from furnace slag from the reduction of iron or copper ore. It will be noticed too that the analysis corresponds quite closely to some published analyses of slag. (Compare "Kerl's Handbuch," p. 856, vol. i.)

* Boltzmann, Pogg. Ann., cli, p. 487. Ayrton and Perry, Jour. Tel. Engineers, vol. v, p. 481.

A specimen of the copper slag from the old "Revere Copper Works" in Massachusetts, obtained through the kindness of Dr. Wadsworth, is microscopically and chemically nearly identical with the so-called meteorite. That it is not of meteoric origin thus seems to be settled, but notwithstanding the most positive stories are told about "seeing it fall," "getting pieces while still hot," etc., I have not been able to trace all such stories down. In regard to one of them I learned from the finder of a fragment which came into my hands that "in 1850, while standing upon the shore at Northport in the evening, suddenly the region was lighted and a ball of fire passed over his head from west to east, fell into the water and exploded with a loud noise." Failing to find any fragments he concluded that it struck too far out. In 1881, having heard that pieces of a meteor had been found there, he revisited the spot and at dead low water picked up several, one of which I have. Although the pieces he found were probably old copper slag brought by some vessel in ballast, still the fall of a meteor there cannot be questioned, and it is possible that true meteoric fragments may have been or may yet be found in that reigon.

ART. XIX.—*History of the Changes in the Mt. Loa Craters;* by JAMES D. DANA. Part I. KILAUEA. Continuation of the Summary and Conclusions.

[Continued from xxxiii, 433; xxxiv, 81, 349; xxxv, 15 (Jan., 1888).]

II. SIZE OF THE KILAUEA CONDUIT.

To appreciate the power at work in Kilauea and understand its action we should know, if possible, the diameter of the lava-conduit; and for this we have to look to its condition both in times of eruption and in periods of relative quiet.

In view of the greatness of the discharge in 1823—so undermining, owing to its extent, as to drop abruptly to a depth of some hundreds of feet the floor of the crater, leaving only a narrow shelf along the sides—we reasonably conclude that, at that time, the conduit beneath was of as large area as the Kilauea pit itself—or nearly seven and a half miles in circuit. We may also infer that, immediately before the discharge, wherever there was a lava-lake, the liquid top of the conduit was up to the floor of the crater, and elsewhere not very far below it. The inference is similar from the eruptions of 1832 and 1840. When the floor of the pit fell at the discharge in 1840, it was not thrown into hills and ridges, as it might have been had it dropped down its 400 feet to solid rock in consequence of a *lateral* discharge of the lavas beneath; on the

contrary, it kept its flat surface, thus showing that it probably followed down a liquid mass, that of the subsiding conduit lavas.

But it is probable that the conduit had then, and has still, a larger area than that of Kilauea

At the eruption of March, 1886, when the emptying of Halema'uma'u and its bordering lake, at the south end of Kilauea, was all the visible evidence of discharge, the Solfatara at the north end, two and a half miles from Halema'uma'u, showed sympathy with the movement. For the escape of vapors from its fissures suddenly ceased, as if the *source* of the hot vapors had participated in the ebb, while a few hours before the discharge the vapors were unusually hot, so as to prevent the use of the bath-house (xxxiv, 351). Thus, even now, during a comparatively small discharge, we have evidence that the two distant extremities of the crater are underlaid by inter-communicating liquid lava. Mr. Brigham speaks of hearing, in 1880 (xxxiv, 27) when at the vapor-bath house in the Solfatara, sounds from below, "rumbling and hard noises totally unlike the soft hissing or sputtering of steam," a fact that seems to favor the above conclusion. Further, through all known time, as now, several of the fissures in the Solfatara region have discharged, besides steam, sulphurous acid freely, and this can come only from liquid lavas.

The summit of the conduit must, therefore, be even larger than all Kilauea. To this may perhaps be added the bordering region of fissures and abrupt subsidences; for subsidences or down-plunges indicate undermining, and undermining here means the removal of liquid material from beneath. With this addition to the limits, the width is 16,000 feet and the length as much, *plus* a mile or more to the southwest, where the fissures of 1868 if not also of earlier date, are giving off hot vapors abundantly.

But while this may be the area of the upper extremity of the conduit, the top surface is not a level plane, as the condition of the region above it indicates. A small part of it at all times (with short exceptions after an eruption) has extended up to the surface in Halema'uma'u, and occasionally in other lava-lakes during times of special activity; for each such lake, however small, must have its separate conduit reaching down to the general liquid mass and giving upward passage to the working vapors. We learn hence that whatever the number of these conduits, they may act independently, that is overflow, and rise and fall in level, because the size is very small compared with that of the reservoir from which they rise.

III. THE ORDINARY WORK OF KILAUEA.

By the ordinary work of Kilauea is here meant the work which is carried on between epochs of eruption. A large part of it is the living work of the volcano, the regular daily action, never permanently ceasing except with the decline and extinction or withdrawal of the fires. The deep-reaching conduit of lavas, which is the source of the heat and center of this living activity, owes a large part of its power to act the volcano, and make a volcanic mountain, to the presence of something besides heat and rocks. Vapors are ever rising and escaping from the conduit, and though lazy in the clouds above where the work is done, they carry on nearly all the *ordinary* action of a crater, even that of greatest brilliancy and loftiest fiery projection as well as the gentler play of the fires. But these vapors have not produced the great eruptions in Kilauea since 1822; they occasion only its quiet or lively activity in periods of regular work between eruptions. I add also, lest I be misunderstood, that the vapors are bad for fuel, as they tend to put the fires out, but good for work.

There is another source of work, perhaps a perpetual source during the active life of a volcano as it is a perpetual source of heat, namely, the ascensive force of the conduit lavas. But, unlike the vapors, it is an invisible agency, slow in its irresistible movements. What are its limitations, and what its source still remain undetermined.

The other agencies concerned in the ordinary work have only occasional effects. They include heat in work outside of the conduit, and hydrostatic and other working methods of gravitational pressure.*

Tabulating the agencies, they are as follows:

A. The vapors.
B. The ascensive force of the conduit lavas.
C. Heat, displacing, disrupting, fusing.
D. Hydrostatic, and other gravitational pressure.

All these agencies do their work around the lava conduit, or its branches, as their central source of energy. Unlike non-vol-

* The following account of Kilauea in December, 1874, was omitted from page 94 of vol. xxxiv. It is from a brief note by Mr. J. W. Nichols, of the British Transit of Venus Expedition of 1874, published in the Proceedings of the Edinburgh Royal Society for 1875–6, pp. 113–17. A low cone around Hale-ma'uma'u about 70 feet high; diameters of the basin ½ m. and ¼ m.; within it, four lava lakes, the largest 200 yds. in length; in the largest, 7 to 8 fountains of white-hot lava playing to a height of 30 to 40 feet, one of them sometimes stopping, and then commencing in another part of the lake; the fountains in every case playing around the edges of the lake; lava of largest lake about 50 feet below the brim; one of the smaller lakes brim full of lava when in the others the lava surface was 30 or 40 feet below the brim; in one, a single fountain bursting from a cavern in its side. The summit crater is stated to have been in action about a month before the visit.

canic igneous eruptions and nearly all other geological operations, the results are *pericentric*. Overflows and outflows, aerial discharges and their depositions, fissure-making, subsidences, elevations, everywhere illustrate this fundamental principle in volcanic action. As the volcanic mountain with its crater is its emphatic expression, so is almost every little heap of lavas, or cinders, that may form within the crater or over the mountain slopes.

A. *The work done by vapors.*

Only part of the work of vapors is of the permanent kind, carried on, as above described, by the vapors rising *through* the lavas of the conduit. Another efficient part, but most efficient in times of eruption, is dependent on vapors generated *outside* of the conduit. In addition, there are the chemical effects of vapors. The work includes:

(1) The effects of the expansive force of vapors in their escape from the liquid lavas: projectile action and its results.

(2) The effects of the expansive force of vapors within the liquid lavas: vesiculation and its results.

(3) The effects of vapors generated outside of the conduit: fractures, displacements, etc.

(4) The chemical action of vapors; which is considered only as regards certain metamorphic effects, in connection with the account of the Summit crater.

1. THE VAPORS CONCERNED: THEIR KINDS AND SOURCES.

The vapors of Kilauea have not yet been made a subject of special investigation. Still, there is no question that the chief *working* vapor is the vapor of water; besides which there is a little sulphur gas, and probably some atmospheric air. Investigations elsewhere have shown the vast predominance of water-vapor among aerial volcanic products proving that less than 1 part in 100 is vapor of any other kind. The statement of Mr. J. S. Emerson (xxxiii, 90) that on the west margin of Halema'uma'u, at one of his surveying stations in April of 1886, to leeward of a "smoke-jet," he continued his work "without regard to the smoke which the wind carried over him within a few feet of his head," is proof that the air held little sulphurous acid. Great volumes of vapors were constantly rising from Halema'uma'u in August, 1887.

Mr. Brigham was led to conclude from his seeing so little vapor rising from the Great Lake during his visit, that too much influence had been ascribed by others to water;* and this view is presented also by Mr. W. L. Green, of Honolulu,

* Brigham, Memoir, p. 450, and this Journal, xxxiv, 24.

who refers part of the movements in the lake to escaping atmospheric air; the air being supposed to be carried down by the splashing and jetting lavas, there to become the source of the splashing; and to become confined in this and other ways, and be carried deeper for other work.* But the amount of vapor escaping from a lake in times of moderate activity, when it is mostly crusted over, is very small—being only that from the vesicles (p. 194) and breaking bubbles in the actively liquid portion; and in a state of brilliant action, the hot air above, up to a height where the temperature is diminished from that of the liquid lavas to 300° F. will dissolve and hold invisible nearly 5 times as much moisture as at 212°; up to 440°, 16 times as much; and to 446°, 27 times. The absence of vapors over a flowing lava stream is made evidence against the presence of water; but if all is from one source, *there should be none* except at the source (ibid.)

The amount of sulphur in the vapors, and its condition before the escape from the lava, whether as sulphur vapor simply or as sulphurous acid (sulphur dioxide), are questions for the future investigator. Pyrite, or some iron sulphide, being its probable source, I add that I have detected pyrite in the lava of a dike on Oahu, but not in the lavas of the crater, where we should hardly expect its presence. Chalcopyrite (copper pyrites) may also be present; for, in 1840, I found, at the southwestern sulphur banks, some blue copper sulphate.† The faintly greenish tint of the flames which have been seen (xxxiv, 24, 356) may have this source.

Carbonic acid has not been observed escaping from fumaroles about any part of the Hawaiian Islands, and no fragments of limestone have been found among the ejectamenta of Kilauea or Mt. Loa The volcanoes stand in the deep ocean, and the conduit must come up through old lavas for thousands of feet, and hence carbonic acid is only a possible not a probable product. The position of the volcanic region in mid-ocean, where continental geological work has, most probably, never gone forward, makes it questionable whether limestone is passed through by the hot lavas at any depth.

The presence of *hydrogen* among the escaping vapors remains to be determined. The pale, hardly bluish flames seen about the Great Lake may come from the burning of escaping hydrogen, or of sulphur vapor, or of hydrogen sulphide.

The *source of the water or moisture*, whence comes the chief part of the escaping vapors, is probably atmospheric. On this point the arguments appear to be as strong now as in 1840.

* Vestiges of the Molten Globe, Part II, 8vo, Honolulu, 1887.

† My Exped. Report, pp. 180, 201, 202, the last containing an analysis.

Kilauea is situated, like Hilo, in a region of almost daily mists or rains, and if approaching Hilo in the precipitation, as is probable, over 100 inches of rain fall a year. Tables give over 200 inches some years for Hilo. The whole becomes subterranean except what is lost by evaporation; for, owing to the cavernous and fissured rocks, there are no running streams over the eastern or southeastern slopes of the island south of the Wailuku river which comes down from the northwest to Hilo. That which falls into the crater and on its borders gives moisture to the many steaming fissures; and sometimes it makes a steaming area of the whole. But this part has very little to do with the volcanic action.

A part of the subterranean waters follow the underground slopes seaward, as shown by copious springs in some places near the shores; and these also take no part ordinarily in the volcanic work. But another part must descend by gravity vertically, or nearly so, and keep on the descent far below the sea level. It has been shown on a former page (p. 16) that much the larger part of the eruptions have occurred in the months from March to June, and this appears to indicate a dependence of the action to some extent, on the abundance of precipitation.*

Moisture may be gathered also from all moist rocks along the course of the conduit in the depths miles below the reach of superficial waters, as suggested by different writers on volcanoes. But any dependence on the amount of precipitation would show that this is not its chief source.

Another source of water is the sea. But sea-water could not ordinarily gain access to the conduit except at depths much below the sea-level, on account of the abundance of subterranean island waters pressing downward and outward. Further, no one has yet reported evidence of the presence of marine salts, or chlorides, beyond mere traces, among the saline products of Kilauea or Mount Loa after an eruption.

A third source of moisture is the deep-seated region in or beneath the crust whence the lavas come. Of this we know nothing. The fact that the presence of such moisture below would make this a dangerous earth to live on has been urged against the idea of such a source.

Since all ordinary action in Kilauea, and also in Mt. Loa, is of the quiet non-seismic kind, the introduction of water into the conduit must be an ordinary and a quiet process, not one of sudden intrusion through fissures. Sudden intrusions may

*This view with regard to the sources of the waters is sustained by several writers. It is well presented, with explanations at length as to the water line in the volcanic mountains, in a paper on "the Agency of Water in Volcanic Eruptions," by Prof. Joseph Prestwich, Proc. Roy. Soc., xli, 117.

sometimes take place for eruptive effects, but of these we are not speaking. The facts from the vesiculation of some lava-flows of Mt. Loa brought out beyond (page 195) give further evidence as to the quiet molecular occlusion of the waters. Moreover, the possibility of this method of imbibition appears to be demonstrated by Daubrée's experimental work, which proves that the process will go on through capillarity or molecular movement, against the opposing pressure of vapors within.* He uses the fact to explain the origin of volcanic vapors.

The water seeking entrance in the depths below, moreover, is under pressure from above, and, whatever the temperature, the forcing of it back against this pressure and friction is impossible; the expansive force generated by the heat only forces it into the rising lava of the conduit, as urged by Mallet, and sustained by Prof. Prestwich.

I proceed now with the consideration of

2. THE EFFECT OF THE EXPANSIVE FORCE OF VAPORS IN THEIR ESCAPE FROM THE LIQUID LAVAS: PROJECTILE ACTION.

All the lava-lakes of the crater, whether one alone exists or many, and the smaller vents over fires that are concealed but not at too great depths, send forth vapors, which, in their effort to escape as bubbles through a resisting medium, that is, the lavas, do projectile work. The vapors thus produce the play of jets over lava lakes with the muffled sounds and tremor of ebullition; and also the splashing and the throwing of spray from open fire-places in the crusted lakes. They dash up the melted fragments from a blow-hole with a rush and roar "rivalling sometimes a thousand engines," thus introducing the coarser effects of gunnery into Kilauea. They make the thin crust of the crusted lake to heave and break, press into rope-like folds the lava along the red fissures, or start a new play of fiery jets, high or low, and frequently several in alternate play; or, they make openings and push out a flood of lava; and occasionally, when rising in unwonted volume, they make lava-fountains of unusual heights over the lakes, with at times loud detonations.

The projectile force required to throw up jets of lava to the ordinary height they have in times of brilliant activity, thirty feet or so (see pages 31, 32), is even less than a calculation from the height, diameter and density would make it, because the

* Géologie Expérimentale, 2 vols., 8vo, Paris, 1879, p. 235.

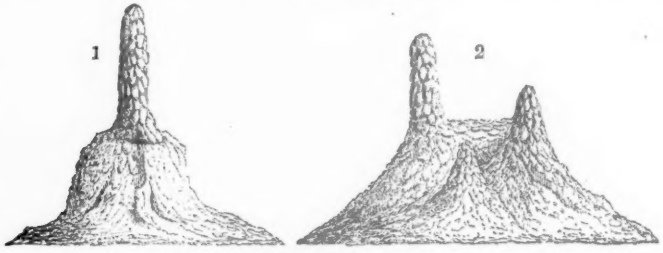
The temperature of the liquid lava is nearly that of the dissociation temperature of water—1985° F. to 2370° F. according to M. H. St. Claire Deville,—and higher than this no doubt at depths below. But that dissociation takes place within the conduit, under the pressure there existing, is not satisfactorily proved.

jets before they reach their limit usually have become divided into clots, instead of remaining a continuous stream.

The fact that the throw in the projectile action of a crater is usually vertical is well shown in some of the columnar driblet-cones This is the case in that of fig. 1 below, in which the column was elongated vertically, although a result of successively descending drops. In the figure referred to, the place of ejection was at the base of the vertical part, and it is probable that the force which determined the slight obliquity in the throw required for so uniform a fall on one side of it, was that of the prevailing wind. This vertical throw,—due to the fact that the top of the bubble is the weak, and, therefore the exploding spot—makes the projectile action good for throwing up, but not good for a destructive bombardment of a crater's walls.

Common observations would lead us to expect that in a low state of the fires, when the large lake is for the most part thinly crusted over, the point of greatest heat and action would be toward the center: instead of this it is usually at the margin, and often in oven-like places partly under the cover of the border rocks. The only explanation that now appears is this: that along the border, the outside cold, or that of the atmosphere, is much less felt than over the central portion.

One of the *secondary results*, over the floor of the crater, of the projectile work is the making of the fantastic *driblet cones*, formed often about blow-holes out of the descending clots and drops, as already explained. The forms of two of these cones are shown in the following figures: the first from my



Driblet Cones.

Expedition Geological Report (page 177) representing a fountain-like structure about forty feet high made of lava-drops; the other from Mr. Brigham's Memoir (page 423), representing "the Cathedral" as seen by him in 1864, and also earlier and later by Mr. Coan (xxxiv, 88).

Occasionally the particles of the projected lava are small and descend in small showers of loose smooth-faced but variously

shaped bullets and granules around the vent; and this is the nearest the crater at present comes toward producing cinder-cones.

Besides making driblet-cones, the projectile work raises somewhat the borders of the lakes. Further, the small overflows, lapping in succession over the borders, often make them steep, and keep increasing their height until a heavier out-flow sweeps one side or another away.

A third incidental result of the projectile action is the making of *capillary glass*, or *Pele's hair*, from the glassy part of the lavas. In the jetting and splashing of the lavas, the flying clots and drops pull out the glass into hairs, just as takes place in the drawing apart of a glass rod when it is melted at middle. This is the explanation of Mr. Coan and others who have observed the action. Mr. Brigham says that "the drops of lava, thrown up, draw after them the glass thread, or sometimes two drops spin out a thread a yard long between them." His new observations of 1880 (xxxiv, 22) accord with this explanation but are remarkable for the length and size of Pele's tresses that he reports as hanging from the roofs of the fiery recesses. In my visit in 1840 to one of the smaller boiling lakes, I saw the rising and falling jets, and the work of the winds in drifting the spun glass; but my conclusion erred in attributing the spinning also to the winds.

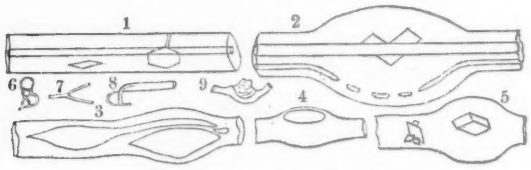
Captain Dutton's observations led him to another explanation, as follows:* "The phenomenon of Pele's hair has generally been explained as the result of the action of the wind upon minute threads of lava drawn out by the spurting up of boiling lava. Nothing of the sort was seen here, and yet Pele's hair was seen forming in great abundance. Whenever the surface of the liquid lava was exposed during the break up the air above the lake was filled with these cobwebs, but there was no spurting or apparent boiling on the exposed surface." He then speaks of the vesicles made by the energetic escape of water-vapors, as solidification at the surface commences, and of their "walls as capable of being drawn out into threads as in the case of glass." The descending of the pieces of cooled crust "produces eddies and numberless currents in the surface of the lava;" and as a consequence "the vesicles are drawn out on the surface of the current with exceeding tenuity, producing myriads of minute filaments" and the air agitated by the heat "lifts and wafts them away." "It forms almost wholly at the time of a break-up; the air is then full of it."

The microscopic structure of the capillary glass has been studied with care by C. Fr. W. Krukenberg.† In his fifty

* Report, p. 108.

† Micrographie der Glasbasalte vom Hawaii; petrographische Untersuchung, 38 pp. 8vo, with 4 plates; Tübingen, 1877.

figures, a few of which are here copied, the glassy fibers are sometimes forked or branching; sometimes welded at crossings; often contain air-vesicles (3, 4), and microscopic crystals (1, 2, 5); often tubular (1, 2) through the drawing out of a minute



Pele's Hair. (Krukenberg.)

air-vesicle. They also show that the air-vesicles sometimes continued expanding as the glass was drawn out; and that the hair is often enlarged about enclosed crystals. The crystals are rhombic, as in the figures. The facts make it evident that the glass is far from being pure glass.

3. THE EFFECTS OF THE EXPANSIVE FORCE OF VAPORS WITHIN THE LAVAS: VESICULATION AND ITS MECHANICAL EFFECTS.

a. Origin.—Vesiculation, the making of bubble-like cavities in a melted rock, is a noiseless unseen effect of the vapors that are rising and expanding *within* the lavas. The expansion necessary to produce them is resisted by the cohesion in the lava, and by the pressure. Consequently it is a very common feature of the easily fusible volcanic rock, basalt, but not of trachyte or rhyolyte, except in pumice, the glassy scoria of these rocks; and even this glass (obsidian) commonly holds to its moisture, if it contains any, without vesiculating.

Owing to superincumbent pressure, the maximum depth of vesicles is small, as has long been recognized; but how small in basalt, or any other rock, has not been ascertained by experiment. It probably does not occur in the Hawaiian Islands below a depth of 200 feet. Above the lower limit, vesicles may increase in number and size toward the surface, and be largest in the scum or crust, as within Kilauea; but this variation upward is not always a fact.

b. Kinds.—Five styles of vesiculation may be distinguished in the Kilauea ejections, two of which characterize stony lavas, and three scorias.

(1) That of the ordinary lava-stream of the floor of the pit. The vesicles are oblong and of irregular shape, and constitute from less than 1 to 50 or 60 per cent of the mass of the rock. The form is spherical when the vesicles are very few and small.

(2) That of the common stony *spherically-vesiculated* lava. The vesicles make 30 to 60 per cent of the mass, and are too

small to be elongated much by the flow. This kind of lava occurs in streams outside of Kilauea, and in many about the slopes of Mt. Loa.

The best example of it I have seen, and the basis of the following description, is that of the 1880–'81 Mt. Loa flow, near Hilo. The small uniformly crowded vesicles constitute about 40 per cent of the mass. They characterize the lava, with scarcely any change in size and numbers, to a depth (as I found in a tunnel within the lava stream whose floor was similar) of 10 or 12 feet. Below this depth of 10 or 12 feet, the lava, as I learned from Rev. E. P. Baker of Hilo, is probably more solid, this being usually the case.

The scoriaceous kinds are:

(3) That of the glassy scoriaceous crust of the lava stream inside of Kilauea, and of the scum of its lava-lakes (xxxiv, 354). The vesicles are 65 to 75 per cent of the mass; they are elongated; those at top mostly closed; those of the bottom of the crust commonly very large. The crust of the lake is sometimes so thin that stones thrown on it slump through. The glass is easily fusible and hence its rapid fusion and cooling. An analysis of this scoria-crust made, at my request, by Professor O. D. Allen, proved it to have the composition of ordinary basalt.* No analysis has been made of the stony lava of Kilauea for comparison.

(4) Ordinary scoria, such as is common about cinder-cones outside of the crater, mostly stony in texture; the vesicles 65 to 95 per cent of the mass.

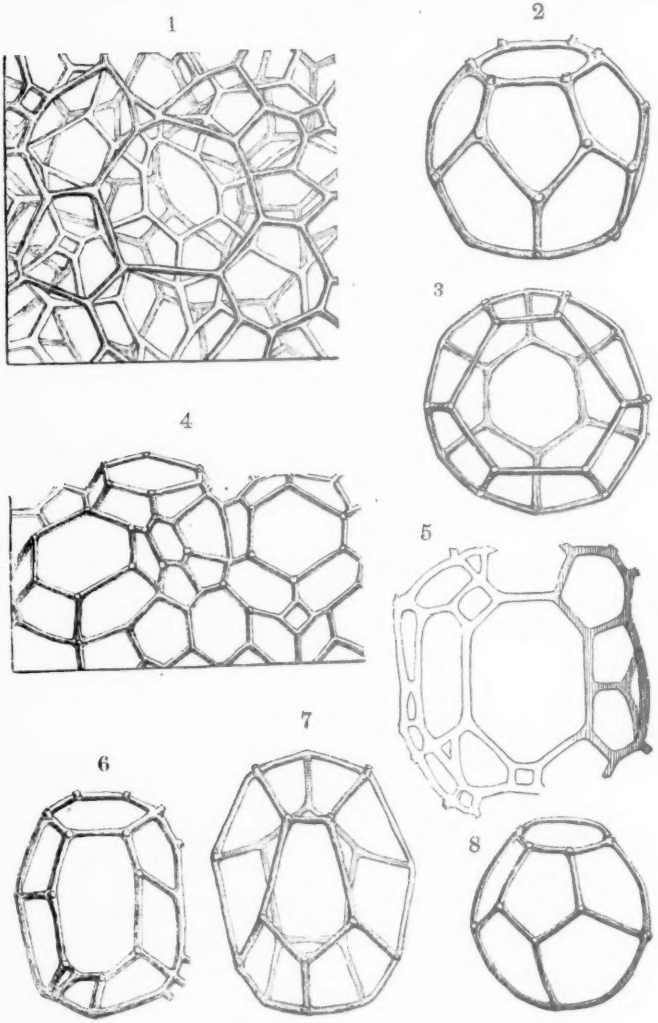
(5) Spongy, thread-lace glass scoria, occurring as a layer 12 to 16 inches thick over the southwestern border of Kilauea (xxxiv, 359); the vesicles 98 to 99 per cent of the mass; their walls in the coarser varieties sieve-like or reticulated; in the finer, like thread-lace in texture. Similar spongy scoria is reported as occurring at the summit of Mt. Loa and about the sources of some of the Mt. Loa lava-flows; but I have seen no specimens. Since a cubic inch of the finer thread-lace scoria contains only 1·7 per cent in bulk of rock material, a layer of solid

* Professor Allen's analysis (this Journal, III, xviii, 134, 1879) is in column A, below. For comparison, the composition is added of (B) the doleryte (diabase) of West Rock, New Haven, Conn., of Triassic age, by Mr. G. W. Hawes (Ibid., ix, 186, 1875), and of (C) a "typical" basalt from Buffalo Peak, east of the west fork of the Platte, between the two Parks, by R. W. Woodward (Geol. 40th Parallel, vol. ii, Descript. Geol., p. 126, 1877).

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	ign.	P_2O_5	
A	50·75	16·54	2·10	7·88	*trace*	7·65	11·96	2·13	0·56	0·35	----	= 99·92
B	51·80	14·21	3·55	8·26	0·42	7·63	10·68	2·15	0·39	0·63	0·14	= 99·86
C	49·04	18·11	2·71	7·70	*trace*	4·72	7·11	4·22	2·11	1·29	TiO_2 2·46	= 99·47

I add that I do not cite here the analyses of the rocks and volcanic glass of Kilauea made by another for me and published in my Expedition Report, because they are erroneous and should be rejected.

basalt glass one inch thick would be sufficient to make a 60-inch layer of the spongy material; and probably a 75 to a 100-inch



Cells of the Thread-lace Scoria.

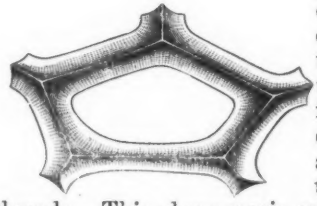
layer of the much more common, coarser variety, in which are some large vesicles occasionally half a cubic inch in size.

The vesicles of the finer kind are mostly $\frac{1}{30}$th to $\frac{1}{40}$th of an inch in diameter, like those of the 1880–'81 Mt. Loa flow; but their walls are reduced to threads corresponding to the edges of polygonal vesicles. Figure 1 shows the general appearance of the surface in a magnified view. The forms of the skeleton polygonal cells are, for the most part, either 12-sided or 14-sided figures, having a perimeter of ten or twelve pentagonal faces in two alternating rows, and bases of five or six sides. The 12-sided cells are bounded by the edges of pentagonal dodecahedrons such as come from the mutual pressure of spheres, except that they are distorted usually by compression, and by elongation or abbreviation. The 14-sided, which are much the most common, are similar to the 12-sided in general form, but have hexagonal bases. Fig. 2 is a side view and fig. 3 an end view of one of the latter kind, and fig. 4 shows a group of such cells, as seen over the surface of the scoria (a cut or broken surface, for it is impossible to handle a piece of the scoria without breaking off bits of the brittle threads). Fig. 6 is another of the 14-sided kind of less symmetrical form, as is common. One of the pentagonal dodecahedrons is shown in fig. 7, and another in fig. 8.

There is often a more complex system of network through other crossing contour-threads, but the simpler forms are referable to those represented. The inside of the base of one of the large and therefore less regular forms is shown in fig. 5, the diameter was about $\frac{1}{20}$th of an inch. In the largest vesicles the walls are openly reticulated.

The threads of this thread-lace scoria are not rounded, but

9.



parts of the contours of the three elliptical cells that were there in contact; and fig. 9 shows a portion of one. Having this form, the glassy material of the threads is thickest, and therefore of darkest color, at the center; and they are still thicker and darker at the angles or junctions of three threads. This glassy scoria calls to mind the vesiculation of an obsidian by a high heat, converting it into pumice or scoria because of its occluded water, as illustrated by Professor Judd, and also by Mr. Iddings in experiments with the obsidian of the Yellowstone Park. The Kilauea glass must have been penetrated molecularly with water to have produced such a result. Its ejection took place after the violent projection of great stones; and apparently not long after, as it overlies directly the layer of stones. The conditions of origin in the cases about the summit of Mt. Loa I cannot give. But the descrip-

tions seem to imply that the spongy scoria there is one of the results of high jettings or fountain-like throws of the lava during an eruption; it may be a light form of ordinary scoria.

The minute delicacy and brittleness of the threads in this scoria suggests a way of making fine dust by volcanic action, which is much more reasonable than that of mutual friction of projected fragments of scoria of the ordinary kind; it thus helps in the understanding of the lofty dust clouds of Krakatau and Tarawera.

c. Amount of moisture required for vesiculation, its distribution, and its origin.—The facts derived from the crowded vesiculated lava of 1880–1881, reaching from its source down to Hilo, over 30 miles, and throughout the whole range remarkable for uniformity and for depth in the stream, besides giving an opportunity to study the origin of the vesiculation and the amount of moisture it requires, presents also evidence as to the origin of the moisture in the conduit and its condition.

(1) As I learn from Rev. E. P. Baker, the vesicles change little toward the summit except in becoming coarser, with thinner walls, at the source. From the mean size, $\frac{1}{3}\frac{1}{5}$ inch in diameter, we obtain for the *size of the particle of moisture* required at the ordinary pressure to fill one of the vesicles, ·000,000,007 of a cubic inch. What the size actually was, under the pressure and the temperature that existed at the time of vesiculation, cannot be determined. But this much we learn, that the moisture was distributed throughout the lava in a state of extreme division, actually or essentially that of molecular diffusion.

(2) The space in the vesicles is 40 per cent of the mass, as determined from the specific gravity of the rock-material, 2·98, and that of the mass with the surface varnished to exclude the water, 1·88. The required water is hence ·0003 per cent of the mass; or by weight ·0001 per cent; showing that, *the amount of water required for the vesiculation is exceedingly small.*

From the thread-lace scoria we find, since only 1·7 per cent of the mass is solid glass, that the amount of moisture required to produce the vesiculation, at the ordinary pressure, would be 3·125 per cent of bulk, and 1·1 per cent by weight The amount of moisture was hence not unusual for a rock, although the vesicles occupied 98·3 per cent of the mass.

(3) The source of the flow of 1880, 1881, according to Mr. Baker, was about 11,100 feet above the sea-level. This is 2575 feet below the summit of Mt. Loa, or about 1600 feet below the bottom of the summit crater. Before the outbreak, the liquid lavas were active within the crater; that is, the length of the conduit above the place of outbreak was then about 1800 feet. On account of the pressure of 1800 feet

of liquid lava no vesiculation could have taken place at this depth inside of the conduit; but at the discharge, the lavas escaped from the pressure, and the vesiculation by means of the diffused moisture must have then begun. Whether the vesiculation for the whole stream took place at or near the source cannot be decided without more knowledge of the flow and its actual sources than we now have. (See further on the Summit crater, in a future part of this paper.)

(4) The facts also tend to sustain the conclusion, before expressed, that the ingress of the subterranean waters, whatever their source, took place by molecular absorption; for it produced an essentially equable molecular distribution

d. The distribution and functions of moisture after reception into the conduit.—(1.) The above conclusions from the vesiculation have prepared the way for additional deductions as to the distribution and movements of the moisture in the conduit. After its reception, it is exposed to a heat at least 1500° F. beyond the critical point of water (773° F.) and retains the temperature of fusion to the surface. If the expansive force has at the ingress under the pressure any effective value, the accession of the moisture will diminish somewhat the density of the lava, that is, increase its bulk; and this increase will be greatest along the central region of the conduit because this is the region of greatest heat. If dissociation takes place, the increase is still greater, as it adds to the bulk of the moisture. It is a question, therefore, whether the pressure of the denser *lateral* lavas of the conduit would not have some effect toward producing an upward movement along the hotter central region.

(2) The mechanism of the volcano, as regards these inside vapors, seems then to be this: (1) a molecular absorption, at depths below, of subterranean waters from regions either side; (2) a rise of the lavas, thus supplied with moisture, along the conduit from some cause (see beyond on "the ascensive force of the conduit lavas") and perhaps partly in consequence of the vapors present; (3) after reaching a level where the pressure is sufficiently diminished, a union of the molecules of water into gas-particles, *producing* by their expansive force *vesiculation;* (4) a further union of particles into bubbles, when the vapors are sufficiently abundant, in order to exert the greater expansive force required to escape through the surface of the lavas, *producing projectile results.*

e. Mechanical effects of vesiculation.—Vesiculation tends in a quiet way to increase bulk, as the above mentioned facts illustrate. It therefore will give increased height to the liquid lava in a conduit. How deep down this effect is appreciable is a point of much importance in its bearing on the movements

and levels of the lavas of conduits. If only to a depth of 200 feet, an average of 20 per cent. of vesicles would add only 40 feet to the height or level of the surface.

But if the vapor particles at all deeper depths are, through their expansive force, undergoing gradual expansion as they work their way or are carried upward, we are still further in the dark as to the amount of effect of vapors on the bulk of the lavas in a conduit. After my observations of 1840, I was led to question, as I state in my Expedition Report, whether the effects from this means might not be sufficient to account for much of the excess of elongation of the Mt. Loa column over that of Kilauea. This is obviously not so. But how much the elongation, is an important question, and it has still to remain unanswered.

4. WORK OF VAPORS GENERATED OUTSIDE OF THE CONDUIT: FRACTURES, DISPLACEMENTS AND OTHER RESULTS.

The conduit has hot rocks around it; and beneath the floor of the crater there are hot rocks about and over its upper extremity. The descending waters are driven back as vapor, and usually in a harmless manner. But a sudden incursion of subterranean waters happening under any circumstances, might produce confined vapors of great force. The natural effects of the pressure of such confined vapors are fractures, elevations and subsidences, and, where pressure is brought to bear in a confined place on a source of liquid lavas, their injection into any open fissure at hand.

These effects belong mostly to times of eruption; but in a lighter form, they may be part of the ordinary work of the crater. The lava-lakes of the bottom, even in quiet times, often have large over-flows, and also out-flows through fissures, that is both *superfluent* and *effluent* discharges; and it is probable that the cause here considered may be the occasion of part of them.

Confined vapors are often generated also by the action of the heat of a lava-flow on moisture underneath. As rains fall almost every day at Kilauea, there must be more or less moisture underneath many parts of the cold floor; and if a few hours flow from the great lake should flood it with liquid rock, its 2000° F. which the bottom of the stream carries along and does not at once lose, would make vapor out of the moisture, having great expansive force. The large dome-shaped bulgings of the lava-streams and other undulations of the surface are thus accounted for on a former page (xxxiv, 356); and many of the steaming fractures of the floor as well as those of the domes may have the same origin.

The next topic under the head of the Ordinary work of Kilauea is "the Ascensive force of the conduit-lavas."

[To be continued.]

ART. XX.—*The Taconic System of Emmons; and the use of the name Taconic in Geologic nomenclature;* by CHAS. D. WALCOTT, of the U. S. Geological Survey. With Plate III.

THE nomenclature employed in classifying geologic formations and terranes should be based upon priority of definition and upon the accuracy of the original observations; the latter to be judged by the testimony of the formations within the areas where they were first made. If the original proposer of a name bases it upon such errors of observation and interpretation that subsequent observers cannot verify his work, and the name can only be used by dropping a name proposed as the result of accurate observation and definition, the latter should be retained.

There is another principle that has been frequently overlooked in discussions relating to the nomenclature to be applied to geologic formations and groups of formations forming terranes. It is this: In the evolution of stratigraphic and historic geology, stratigraphic geology preceded paleontologic stratigraphy: that is, the succession of strata for a given geologic province was first determined and then the succession of organic remains in the strata. This has been so far perfected that, in most instances, the known succession of life in a geologic terrane in one province can be compared with that in some other not geographically connected with it: also, different sections of strata in the same province may be compared with one another when the continuity of the strata is broken. From this it follows: First: that the unit of geologic nomenclature is the formation as lithologically determined, and the combination of these units in any given section builds up the greater geologic divisions. Second: that the means of correlation of the formations and terranes of one province with those of another, is by the order of succession, as stratigraphically determined, of the contained organic remains of the respective formations and terranes.

A paleontologist should rely largely upon the evidence of geologic age furnished by the fossils; but, at the same time, as a geologist, he should endeavor to obtain their stratigraphic position and order of succession in each geologic province. An example of the desirability of this is shown by the vertical distribution of the Devonian fauna in central Nevada, where several species of the Lower Devonian fauna of New York occur at the Upper Devonian horizon, in the Eureka district. (Introduction to Monograph viii, U. S. Geol. Survey).

With the preceding statements in mind, I take up the question of the "Taconic System" in geology, as one that can only be intelligently understood and decided by the application of the principles contained in them.

In pursuance of a general plan the subject matter is arranged under the following heads:

1. The Taconic Area and geologic work within it.
2. Geology of the Taconic Area as known at the present time.
3. Geology of the Taconic Area, as known to Dr. Emmons.
4. Comparison and discussion.
5. Nomenclature.

THE TACONIC AREA AND GEOLOGIC WORK WITHIN IT.

The Taconic Area.—The Taconic area includes the Taconic range which trends north and south, nearly on the boundary line between the States of New York, Vermont, Massachusetts, and Connecticut, and the country immediately adjacent to the range, on the east and west. In this area Dr. Emmons first studied and elaborated the theory of the "Taconic System" of rocks.

For the purpose of re-investigation the counties of Washington, and Rensselaer, N. Y., Bennington, Vt., and Berkshire, Mass., were taken as the typical Taconic area, as they contain sections of all the formations spoken of by Dr. Emmons and, also, nearly all the localities cited by him, where the facts sustaining the theory which he proposed could be verified.

*Geologic work within the Taconic Area.**—Quite early in the course of my study of the history of the investigation of the strata now referred to the Cambrian System in America I became acquainted with the voluminous literature of the Taconic controversy, and learned that two geologists only had studied the typical Taconic area with any considerable degree of thoroughness. They were: Dr. Emmons, who founded the "Taconic System" as the result of his observations, and Professor James D. Dana, who studied the strata referred to the "Lower Taconic" by Dr. Emmons. Before Dr. Emmons entered the

* For an historical review of the field work and also of the opinions relating to the "Taconic System" the reader is referred to Dr. Emmons's memoir in the Agric. N. Y., vol. i, 1847, and to the review of the Taconic System in his American Geology, pt. 2, 1856: also to the various publications of Prof. Jules Marcou on the Taconic System, especially "The Taconic System and its position in Stratigraphic Geology" (Proc. Amer. Acad. Sci. and Arts, vol. xii, 1885); to Dr. T. S. Hunt's memoir on "The Taconic Question in Geology" (Mineral Physiology and Physiography, pp. 516–C86, 1886), also, "The Taconic Question Restated" (Amer. Nat. Feb., March and April, vol. xxi, 1887); Prof. Jas. D. Dana's paper on "The History of Taconic investigation previous to the work of Prof. Emmons" (Amer. Jour. Sci., III, vol. xxxi, pp. 399–401, 1886), and many references in the series of papers on the results of original investigations in the Taconic area, published from 1872 to 1887, by Prof. Dana.

field Professors Dewey and Amos Eaton had studied more or less of the Taconic region, and the data obtained by them were of material aid to Dr. Emmons.

Among others who have examined portions of the area studied by Dr. Emmons previous to 1844, are: Dr. W. W. Mather, of the geological survey of New York, who made a reconnoissance of the portion within New York State (Geol. N. Y., Rep. First Geol. Dist., 1842); Professor James Hall, who examined a section crossing from the Hudson River to the Green Mountains (Proc. Assoc. Am. Geol. and Nat., p. 68, 1845), and the Professors W. B. and H. D. Rogers who studied a section extending from the Massachusetts side of the Taconic area to the Hudson River (loc. cit., p. 67: also, Proc. Am. Phil. Soc., vol. ii, pp. 3 and 4, 1841). The Professors Edward and C. H. Hitchcock described and mapped the strata referred to the "Taconic System" in Vermont, and discussed the question of their geologic age (Geol. Vt., 1862). Subsequently, Professor C. H. Hitchcock made a series of sections, crossing the "Taconic System" in Vermont (Bull. Am. Mus. Nat. Hist., vol. i, 1884). The observations made by Mr. S. W. Ford, from 1874 to 1886, in the counties of Rensselaer and Columbia, N. Y., have furnished important data on the formations examined by him that will be referred to again. Some of the results obtained by the geologists mentioned will be spoken of under the head of "Comparison and Discussion."

Dr. T. Sterry Hunt, Professor Jules Marcou and Professor N. H. Winchell have all written at length upon the "Taconic System," but I have been unable to discover that either of these gentlemen have made any field observations in the typical Taconic area *

In searching for data to aid me in forming an opinion respecting the value of the name Taconic in American geologic nomenclature, I found that there was such a wide divergence of opinion among the geologists who had studied the "Taconic System" in the field and those who had formed opinions upon it from partial observations in other areas, and the data given by Dr. Emmons and the Professors Hitchcock and Professor Dana, that there seemed to be no way to settle the questions at issue except by investigating the original Taconic area and identifying and mapping all the formations within it except the areas mapped by Professor Dana and the Professors Hitchcock. The necessity of ascertaining the age of the different

* Dr. Hunt's later opinions appear to have been influenced by his geologic observations in Pennsylvania, and by certain theoretic views founded on the lithologic characters of the "Lower Taconic" rocks. Professor Marcou examined the extension of the "Upper Taconic" strata in Northern Vermont and Professor Winchell appears to have studied the publications of Messrs. Emmons, Marcou and Ford.

formations by paleontologic evidence, was also imperative, as their lithologic characters were of little comparative value outside of the Taconic area owing to local differences in the original sedimentation and to the subsequent alteration of the strata by metamorphic agencies.

With the assent of the Director of the Geological Survey I began field work during the season of 1886 and continued it until the close of the field season of 1887. A few of the results of this work were given in a paper entitled "Geologic Age of the Lowest Formations of Emmons's Taconic System," and read before the Philosophical Society of Washington, January 15th, 1887, a brief abstract of which was published (this Journal, vol. xxxiii, p. 153, 1887). On the 22d of April, 1887, I read a paper before the National Academy of Sciences, at Washington, bearing the title: "The Taconic System of Emmons." In it were given the results of my studies up to that date; and I exhibited a geologic map, and a cross-section, of the Taconic area. As I was soon to return to the field this last mentioned paper was not published.*

Previous to studying the geology of the Taconic area I worked during portions of the field seasons of 1883–4 on the "Upper Taconic" strata of Northern Vermont and published a part of the results in the introduction to Bulletin Thirty of the U. S. Geol. Survey, 1886.

GEOLOGY OF THE TACONIC AREA AS KNOWN AT THE PRESENT TIME.

The section (see map)† crossing the Taconic area shows the general position and relation of the strata, and their geographic distribution is given on the map. In a report on the geology of Washington County, N. Y., I shall describe the geologic section in detail. For the present purpose, however, the section and map, supplemented by notes on the geologic formations, will I think give the data required for a clear understanding of the geologic terranes. Beginning on the east, the terranes will be mentioned in the order they are met with in passing westward from the pre-Cambrian crystalline gneisses of the Green Mountains to the Hudson River, and each will be given a number by which to identify it in subsequent references.

One of the best localities to see the contact between the pre-Cambrian crystalline gneiss and the overlying, bedded quartzite

* A short abstract of it was sent, June 8th, 1887, to Professor N. H. Winchell, reporter on the lower Paleozoic rocks to the American Committee of the International Congress of Geologists, and was subsequently withdrawn owing to the field work of the season of 1887 having negatived and rendered obsolete several of the conclusions therein expressed.

† To be inserted with the second part of this paper.

is on the western crest of Clarksburg Mountain, northeast of Williamstown, Mass. It is one of Dr. Emmons's typical localities, and it has also been examined by Professor C. H. Hitchcock, who, in speaking of the relations of the quartzite to the Green Mountain gneiss, says:

"3. Still more decisive is the fact that the lowest layer of the quartzite has been derived from the ruins of the gneiss. This stratum is a conglomerate, containing many pebbles of a peculiar blue quartz, and has been observed at Clarksburg, Mass., Sunderland, East Wallingford, Ripton, and in Lauzon conglomerate, at Bristol. (The Geology of Northern New England: royal 4to, p. 2, 1870).

When making observations during the summer of 1887 on Clarksburg Mountain, I found the unconformity between the quartzite and gneiss to be well marked. The lower layers of the quartzite series contain shales and thin beds of conglomerate, and there are no passage beds between the quartzite series and the gneiss in the localities where the bedding of the gneiss and quartzite series appears to be conformable. In accordance with this, the unconformity has been represented in the section.

The quartzite, including certain minor beds of schistose shale, conglomerate and limestone, I will call terrane number one.

Terrane No. 1.—Professor James D. Dana, in describing the Quartzite series, in a paper on the Geology of Vermont and Berkshire, says "Associated with the limestone belt and following mainly its eastern border there is a *quartzyte* series, consisting in Vermont of quartzyte and crystalline slate or schist (hydromica slate, sometimes chlorite slate), and rising at intervals into mountain ridges. This quartzyte formation commences just abreast of the northern limit of the 'Eolian limestone' in Vermont: and it follows it southward through Massachusetts, and into Connecticut, being, throughout, its close attendant" (Amer. Jour. Sci., vol. xiii, p. 38, 1877). And on p. 204: "(4) The age of the Quartzyte formation, and its relation in position to the adjoining limestone.—The quartzyte formation includes, as has been explained, strata of quartzyte and schists—sometimes one predominating, and sometimes the other. The special age of the formation is in doubt, equally with that of the eastern limestones. There may be quartzytes of different periods of the Lower Silurian: and so with the schists. The question of age can be positively answered only by the discovery of decisive fossils in the quartzyte of Vermont: and so many imperfect forms have already been brought to light (besides the unsatisfactory worm-burrows, and Fucoids or worm-tracks) that we feel sure the future will clear away the doubts."

Professor Dana considers that the evidence proves the existence of a limestone beneath the quartzite, in some sections,

but in Vermont Mr. Wing makes the limestone superjacent to the quartzite (loc. cit., p. 204).

As all observers agree on the stratigraphic position of the quartzite series the paleontologic evidence of the age of the terrane, formed by that series, will be now considered.

The Professors W. B., and H. D. Rogers, Edward, and C. H. Hitchcock, James Hall, Dr. W. W. Mather and Professor Jas. D. Dana have all held the opinion that the quartzite (Terr. No. 1) should be referred to the Potsdam horizon and, from its stratigraphic position, the tentative reference was in accordance with the facts known; but, as Professor Dana has said (*ante*), the question of age can only be answered by decisive fossils in the quartzites of Vermont.

During the progress of the geological survey of Vermont, a few fossils were found in the quartzite. On page 356, of the Geological Report, vol. i, 1862,* it is stated: that besides Scolithus, a straight-chambered shell occurs in a hyaline quartz, on the west side of Lake Dunmore, and a species of Lingula in Starksboro, near Rockville; and, on page 357: "In the southwestern part of Woodford there seem to be traces of organisms resembling bivalve shells, about the size of a three-cent piece." I have, through the courtesy of Professor Dana, examined two of the specimens referred to, that are now in the collection of the Peabody Museum, at New Haven, and I find the "Modiolopsis-like shell" to be *Nothozoe Vermontana*, and the straight-chambered shell to be, to all appearances, a cast of *Hyolithes communis*, a Middle Cambrian species.

Professor B. K. Emerson kindly sent to me for examination the specimens from the Amherst college collection mentioned in the Geology of Vermont, and which were collected at Salisbury, Vt. I find one to be *Nothozoe Vermontana* and the other species to be a cast of *Hyolithes communis*, or a closely allied species. In a small collection of fossils, received from Professor H. M. Seely, of Middlebury college, Vermont, who found them in quartzite bowlders on the west slope of Sunset Hill, near Lake Dunmore, there occurs the *Nothozoe Vermontana* described as "from the Potsdam sandstone,"† and, with it, heads of a species of Olenellus undistinguishable from *O. Thompsoni* of the Georgia formation in Franklin County, Vermont; and in other specimens of the quartz rock, collected at the same locality and containing *N. Vermontana* and *O. Thompsoni*, a species of Hyolithes occurs that is undistinguishable from *H. communis*.

An investigation of the reported localities of fossils, made by the writer in June and July, 1887, resulted in the discovery

* Dated 1861, but issued in 1862.

† Bull. Am. Mus. Nat. Hist., vol. i, p. 145, 1884.

that only the Scolithus had been found *in situ*. Professor H. M. Seely had traced the Rockville "Lingula" to a bowlder, taken from a stone wall, and also the reported Lake Dunmore specimens to bowlders on Sunset Hill: no fossils being found *in situ*. In company with Professor Seely, I visited the Lake Dunmore locality, and found fossils in rounded quartz bowlders, but the quartz ledges gave no traces of them. The Woodford locality was too indefinitely described to be found; but as transported bowlders afforded me Nothozoe and traces of trilobitic remains, similar bowlders were probably the source of the specimens mentioned. In Sunderland, east of Arlington, on Roaring Branch, Scolithus occurs abundantly *in situ*, in the quartzite; and angular blocks of quartzite were found, one mile up the ravine, that contained Hyolithes and fragments of trilobites; but they were not traced to the beds from which they were derived. Two miles east of Bennington, however, success attended my search for fossils *in situ*. The section begins in the woods on the west slope of the mountain on the old Weeks farm north of the old Windham turnpike.

Wooded slope, above pasture	75 feet.
1.—Light-gray, nearly white, compact, fine-grained massive-bedded quartzite, with alternating beds of hyaline quartz. Dip 0° to 5° S. E.; strike, N. 35° E. (magnetic)	35 "
2.—Light-colored, bedded quartzite, with brown spots; showing grains of sand and fossils: the latter also in the compact rock. Fossils: Nothozoe, Hyolithes and Olenellus*	40 "
3.—Alternating bands of layers of light-gray and hyaline quartzite, becoming more massive near the summit	325 "
The dip increases from 5° to 10,° 15° and up to 25° S. E., on the line of the section, and a little farther south, to 45° S. E. Strike, N. 45° E. (magnetic)	
	400 feet.

The quartzite was traced north into the valley of Roaring Branch, and it is a continuation of the deposit on the western slope of Bald Mountain; to the south it extends along the west side of the ridge leading to Dome Mountain, in Pownal, northeast of Williamstown, Mass. It caps the latter and crosses the narrow valley on the south to the Clarksburg group of mountains, along the slopes of which it extends to a point opposite Williamstown, where it bends eastward along the south face of

* I have shown elsewhere that the genus Olenellus is characteristic of the Middle Cambrian horizon, over wide areas in North America, and that it is a pre-Potsdam type. (Bull. U. S Geol Survey, No. 30, 1886.)

the mountain, reaching into the valley north of North Adams-Mass. On the western summit of the mountain, toward Williamstown, the quartzite series come in unconformable contact with the pre-Cambrian gneiss; and fragments of a trilobite, apparently the genus Olenellus, were found about one hundred feet above the contact.

As a result of the discovery of fossils, *in situ*, in the quartzite east of Bennington, the fossiliferous bowlders are given a value, as they were undoubtedly derived from the quartzite formation, and were distributed in the valley to the west during Quaternary time and even at the present by floods occurring in the gorges and valleys that cut through the quartzite. It is now a question of search to trace the fossiliferous horizon in the quartzite from Starksboro, to Bennington, Vt. and to Dutchess County, N. Y., where Dr. Mather considered the "Quartzite" metamorphosed Potsdam sandstone, and he so called the compact sandstone of Stissing Mountain, in the northeastern part of Dutchess County, N. Y. (Geol. N. Y.; First Geol. Dist., p. 418, 1843). During the field season of 1886, I had the opportunity of visiting the Stissing Mountain sandstone locality, in company with Professor W. B. Dwight, and we found *Hyolithellus micans* in the limestone layers, resting immediately on the sandstone; and the heads of *Olenellus Thompsoni* in the sandstone, fifty feet or more below the limestone. *Hyolithellus micans* is known only in the Georgia terrane of New York, Vermont and Canada. A species of Triplesia is associated with the Olenellus at Stissing Mountain, but it has little value in the correlation of strata.

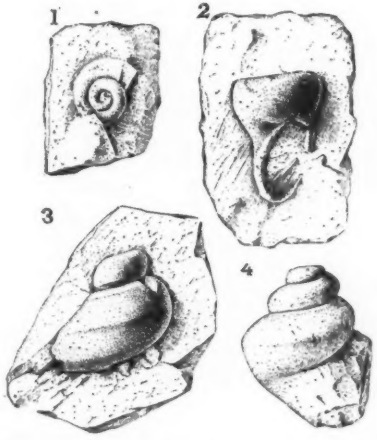
If we now turn to the geologic map, we find that all the localities I have mentioned are on the line of outcrop of the quartzite (Terr. No. 1).

Résumé.—The stratigraphy shows the quartzite series (Terr. No. 1) to be the oldest of the Paleozoic sediments known on the eastern side of the Taconic area, and the contained fauna correlates it with the middle division of the Cambrian, but not as low in position as the fauna of the lower strata of the Georgia Terrane. (See Terr. No. 5.)

Terrane No. 2.—Dr. Emmons, when describing the sections of Graylock (Am. Geol., vol. i, pt. 2, p. 17, paragraph 16), states that the "rock overlying the quartzite is again talcose slate, siliceous at its base, but purely a talcose slate as a mass and which requires no further description. It is between 400 and 500 feet thick and extends up the limestone which constitutes the seventh member of the Lower Taconic system." It is this belt of shales that I have numbered 2 on the sections: and it is assumed to represent, at this point, the Potsdam sandstone of the western side of the Champlain basin. This ter

rane is so much more extensively developed farther west, in the section, that I will omit its description until passing down the western side of the synclinal formed by terrane number three. (See Section on the map.)

Terrane No. 3.—This is the limestone and marble belt that outcrops both on the eastern and western side of the Taconic range. Its distribution is shown on the map and in the section, and I think it unnecessary to restate the evidence given by Professor Dana to prove that this limestone belt is the representative of the limestones of the Trenton-Chazy-Calciferous series of the western side of the Champlain basin. His conclusions are based on the stratigraphy, supported by paleontologic evidence,* discovered by Messrs. Wing, Dana and Dwight on the western side of the Taconic range, north and south of the typical area. The fossils have been referred, however, to the sparry limestone or "Upper Taconic" by those writers who favor the view of the pre-Cambrian age of the "Lower Taconic." Prior to August 5th, 1887, determinable fossils had not been found in the limestone series *east* of the Taconic range. At that date, I found, in the eastern limestone, in the town of Pownal, Vt., about half a mile north of the Massachusetts line, a number of fossils that were weathered out in relief on the surface of a compact, clouded marble. The collection gives Euomphalus? (fig. 1); the lower whorl and aperture of a shell like *Murchisonia bellicincta* (fig. 2); two whorls of a form identical or closely allied to *Murchisonia Milleri* (fig. 3). (fig. 4 is a cast of *Murchisonia Milleri*, from the Cincinnati formation, for comparison with fig. 3): a cross-section and lower whorl of a Raphistoma-like shell, and a large, crushed gasteropod shell. The fauna belongs to the Trenton terrane, and, by it, we can correlate the Eastern with the Western limestone.†



In September, 1887, I found fossils in the limestone on both

* See Professor Dana's papers in Am. Jour. Sci., 1872 to 1887.

† Paper read before the American Association for the Advancement of Science, August, 15th, 1887: "Discovery of Fossils in the Lower Taconic of Emmons."—C. D. W.

the eastern and western side of Mt. Anthony, on the line of strike of the Taconic range. The strata of Mt. Anthony are conformable and form a southwardly-sloping synclinal of limestone and marble, carrying, above, a considerable thickness of shales. On the west side the limestones dip eastward and are well exposed one mile south of the Hoosic post office, N. Y. About 400 feet of limestone are shown in the section, and, near the upper part of it, shales appear which have a schistose structure. The shales are in thin beds alternating with the limestones at first, and then they increase until the interbedded limestone disappears and the typical Taconic "talcose slates" of Emmons are the prevailing rock. In the limestones, nearly 200 feet below the shales, a stratum of limestone from two to four feet in thickness is crowded with shells of the genera Maclurea and Murchisonia. The limestone is compact and hard, so that sections only of the shells could be secured. To any one conversant with the Trenton-Chazy limestones of Washington County, N. Y., both the lithology and fossils of the Mt. Anthony limestone, at this point, would prove the geologic horizon to be that of the Trenton-Chazy. Crossing the mountain to the eastern side, at a point three miles south of Bennington Centre, Vt., abundant fragments of crinoids occur in a dark bituminous limestone, above a band of clouded marble. In fig. 5, a few sections of a column is shown and also the calyx and portions of the arms of a crinoid, allied to *Homocrinus gracilis* of the Trenton limestone of New York. Above the dark shale and dipping westward with it, there is a band of arenaceous limestone upon which I noticed a fragment of an Orthoceras, an Euomphalus-like shell and sections of what appeared to be a Rhynchonella. This limestone is lithologically similar to that conformably overlying a bed of marble that dips toward and passes beneath Mt. Anthony at a quarry, two miles west of Bennington Centre.

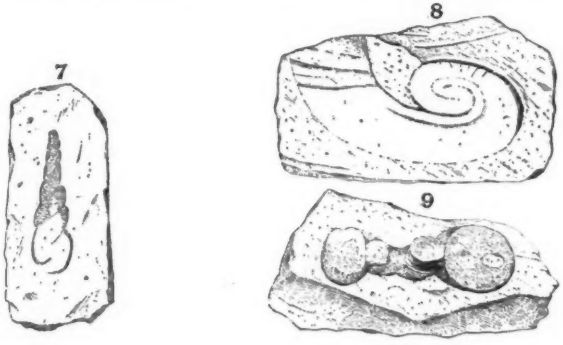
5

I next visited the limestone at the entrance of the Hopper on the north side of Graylock peak, a typical locality of Dr. Emmons's. The limestones and marbles are of the same lithologic character as those of Mt. Anthony with the exception of the bituminous limestone, carrying the crinoids. Several traces of fossils were observed, but only one that could be recognized. It appears to be the inner whorl of a gasteropod related to Euomphalus or Maclurea (fig. 6).

6

Having verified the stratigraphy as published by Dr. Emmons and Professor Dana, and having found Trenton-Chazy fossils in the marble belt, I crossed the Taconic range to its

western base, in the town of Berlin, N. Y. The schists of the range dip to the eastward, have a greenish color, feel talcose to the touch, and appear unlike the dark shales of the Hudson Terrane. Continuing on over the range and down the western slope, I found that the schistose character of the rock was gradually disappearing and that it was becoming more shaly. The greenish color continued, but, toward the western base of the range, a mile north of the village of Berlin, the color began to change, the green and dark shales appearing in the same stratum, and even in hand specimens, and soon the dark shale of the Hudson Terrane was the prevailing rock. A little lower down, the characteristic brown sandstones of the Hudson Terrane began to appear in the shales; and, just east of Berlin village, the limestones appeared from beneath the shales. In other words, it is a repetition of the Graylock and Mt. Anthony sections with the exception of less alteration in the lower part of the shales, and in the limestones. One mile south of South Berlin post office, on the eastern side of the valley, the limestones dip to the east and northeast. At the base of the section there is a considerable thickness of dark argillaceous shale, upon which the limestone rests conformably. Continuing up the west slope of the mountain, more or less impure limestones are met with in which I found *Solenopora compacta*, plates of crinoidal columns, *Murchisonia gracilis?* (fig. 7), and fragments of indeterminable gasteropods. The



Lituites sp?

fossil-bearing limestone is subjacent to, and interbedded with, shales that are succeeded by arenaceous limestones which, in turn, are conformably subjacent to the shales and schists of the Taconic range.

The next locality examined was one described by Dr. Emmons as showing fossiliferous limestones of the Champlain series, resting unconformably upon the "Taconic" schists (Am.

Geol., pt. 2, pp. 73–77, 1856). He studied the section, where it is very much broken and disturbed, and found evidence that sustained his view. If he had gone a mile to the north, he might have discovered that the shales pass conformably beneath the limestone and, also, that shales occur conformably above it. Fossils were abundant at a point one mile north, northwest of Hoosick Falls, and the following species were recognized: *Solenopora compacta*, *Maclurea* sp.?, *Lituites* sp.? (figs. 8 and 9), and *Orthoceras* sp. undet.

On the map the localities, where fossils have been found in this terrane, are indicated by the letter F.

Résumé.—The stratigraphic and paleontologic evidence unite to prove that the limestones and marbles of Terrane No. 3 are the geologic equivalent of the Calciferous-Chazy-Trenton limestones of the Champlain and Hudson valleys, and belong to the system of strata characterized by the second fauna of Barrande.

Terrane No. 4.—This terrane directly overlies and rests in synclinals of the limestones of Terrane No. 3, at Graylock and at other points; and there is no apparent reason to differ from Professor Dana in referring it to the Hudson Terrane.

In regard to the graptolites found in it, near Hoosick, N. Y., I wish to state that I visited that locality and collected specimens of the flattened and distorted graptolites from the smooth shales. On comparing the specimens with those of *Diplograptus pristis*, from the Hudson Terrane, at Fort Edward, N. Y. and, also, from the Hudson Terrane in the western part of the township of Greenwich, Washington County, N. Y., I fully concur with the opinion given by Professor James Hall, in 1847 (Pal. N. Y., vol. i, pp. 321, 322, pl. 72), that the Hoosick shale graptolite is identical with the *Diplograptus pristis* found in the Hudson Terrane, within the Hudson valley.

Terrane No. 2.—In speaking of this terrane as the shale above the quartzite of Terrane No. 1 and beneath the limestone of Terrane No. 3, it was assumed that it represented the Potsdam horizon (*ante*); and we now have to search for the evidence of that horizon between the recognized Georgia horizon of Terrane No. 1, and the Chazy-Trenton horizon of Terrane No. 3. Unfortunately, on the east and west sides of the synclinal, on the line of the section, the shales beneath the limestones are unfossiliferous; but, from the data afforded by the Potsdam or Upper Cambrian strata of Saratoga, Dutchess and Washington counties, N. Y., we obtain a fairly satisfactory identification of the Potsdam horizon in the Taconic area.

In Saratoga County a section occurs where a pure limestone, carrying a well-marked Potsdam fauna, rests directly on a mas-

sive-bedded sandstone.* The sandstone is of Potsdam age, and contains typical fossils in its extension north in the valley of Lake Champlain: in Washington County I found, at Dewey's Bridge, south of Whitehall, fossils in the Potsdam sandstone, and at Whitehall, numerous Potsdam fossils in the limestone layers resting upon the sandstone and beneath the Calciferous formation. The Calciferous formation was subjacent to the Chazy limestone.

In Dutchess County Professor Dwight found the Potsdam fauna in a limestone, three species of which are identical with those at the Saratoga and Washington County localities. This proves the presence of the Potsdam fauna in Dutchess County, not far distant from the sandstone and limestone carrying the Georgia fauna. Although no direct stratigraphic connection is yet known at this point between the limestone carrying the Potsdam fossils, and the limestone resting on the the sandstone carrying the Georgia fossils, there is little doubt, from the known succession of faunas elsewhere, that the Potsdam formation was deposited in its usual position, between the Georgia and Calciferous formations, and that it has been displaced by the subsequent faulting of the strata.

In Saratoga County, the Calciferous-Trenton terranes are superjacent to the Potsdam, and, also, in Dutchess and Washington counties. In all the sections given in Bulletin 30, U. S. Geological Survey, the Potsdam is superjacent to the Georgia Terrane; and I find that Terrane No. 5, beneath the 2,000 feet of greenish schistose shales of Terrane No. 2, is characterized by the Georgia or Middle Cambrian fauna. I think, then, that we may conclude that Terrane No. 2 represents the Potsdam horizon: also, that the latter may be represented in part by sandstone or quartzite on the west side, near the limestones, or, if the same conditions prevail as in Dutchess County, the lower portion of the limestone; the shales and schists beneath the limestone all belong to the Middle Cambrian. To the east of the limestone, the Potsdam Terrane may be represented in part by either (1) the upper part of the quartzite of Terrane No. 1, (2) the lower part of the limestone of Terrane No. 3, or (3) the hydromica shale between the quartzite and limestone, or Terrane No. 2, or by the combination of two or more of these parts.

Terrane No. 5.—In my field work of 1886–'87, I studied with care the slates, shales and interbedded limestones and sandstones that form Terrane No. 5. On the map an interruption is shown midway, by the presence of a broad belt of

* Bull. U. S. Geol. Survey, No. 30, pp. 21, 22, 1886.—I found several species of this same fauna (Dicellocephalus, Ptychaspis, etc.) in sandstone in the upper beds of the Potsdam sandstone, in the vicinity of Chateaugay Chasm, Franklin County, N. Y.; also in a calciferous sandrock of the Potsdam Terrane, at Whitehall, N. Y.

the Hudson Terrane (No. 6), but I did not find that the two parts of Terrane No. 5 are a repetition of the same strata except possibly for a short distance, near the break between them. The upper or eastern portion is formed of green, purple and drab slates, with thin interbedded limestones, carrying characteristic Middle Cambrian fossils; the lower and western part consists of dark and drab shales with interbedded sandstones, calcareous sandrock and limestones that contain Middle Cambrian fossils. About 2,000 feet from the base, the fauna begins to show the presence of the Lower Cambrian or Paradoxides fauna, but not in sufficient force to overbalance the predominating assemblage of Middle Cambrian species.—(See this Journal, vol. xxxiv, p. 188, 1887). Fossils occur more or less abundantly at over 100 localities as now known to me within the typical Taconic area, and they are distributed at various horizons throughout the 14,000 feet or more of strata referred to this Terrane.

An examination of the sections and the faunas of Terrane No. 1 and Terrane No. 5, shows that the former is stratigraphically and faunally the equivalent of the upper or eastern part of Terrane No. 5, Terrane No. 1 being the sandy deposit of the shore line, and No. 5, the off-shore accumulation of finer sediment.

Terrane No. 5, like No. 1, is referred to the Middle Division of the Cambrian.

Terrane No. 6.—This is a belt of red, black and green slates, cherts and sandstones faulted in between the two parts of Terrane No. 5. The contained graptolites show it to be a portion of the Hudson Terrane. Its distribution and relation to the other terranes is shown on the map and in the section.

Résumé.—I have briefly noticed the strata included within the Taconic area with the exception of the beds west of the great fault line, separating Terrane No. 5 from the recognized strata of the Calciferous-Chazy-Trenton and Hudson terranes. Along the line of the fault, the strata of Terrane No. 5 are usually thrust against, and, sometimes, over and upon, the latter, but in no instance have I been able to find an unconformity by original deposition between the strata of Terrane No. 5 and the strata of any of the superjacent terranes. This will be more fully described later under the head of Comparison and Discussion.

In the preceding pages, the strata of the Taconic area are grouped under six terranes and identified as follows.

Terranes Nos. 1 and 5=Middle Cambrian.*

Terrane No. 2=Upper Cambrian.*

Terrane No. 3=Calciferous, Chazy and Trenton limestones.

Terranes Nos. 4, and 6=Hudson shales, sandstones, etc.

[To be continued.]

* For a description of the term Cambrian as used in this paper see this Journal, III, vol. xxxii, pp. 138–157, 1886.

ART. XXI. — *On the crystalline form of Polianite;* by EDWARD S. DANA and SAMUEL L. PENFIELD.

THE true crystalline form of manganese dioxide, MnO_2, and the relation to each other of the two minerals having this composition—the common soft variety and the rarer hard form—have long been uncertain points in Mineralogy. The name *pyrolusite* was given by Haidinger* in 1827 to the mineral which had been earlier called Grey Manganese Ore (Grau Braunstein in part of Werner, 1789, and Hausmann, 1813). Haidinger also gave a partial description of crystals, with a figure which is reproduced in Dana's System (1868, fig. 171, p. 165). The only angle given is that of the prism 86° 20′, to which Hausmann (1847) added that of a brachydome $d = 40°$ (over the base).

In 1844 Breithaupt† gave the name *Polianite* to the anhydrous MnO_2 from Platten, Bohemia, which, as he showed, had a hardness almost equal to that of quartz. He insisted, further, that the common soft MnO_2 (*Weichmangan*, Germ.) was not an independent species but only an alteration product from other minerals, chiefly manganite, but also in part from polianite. Breithaupt's description of the form of polianite is very imperfect; he gives the angle of the prism as 87° 8′, and mentions the occurrence of the three pinacoids, a brachydome inclined to the brachypinacoid 62°, and two macrodomes.

The subject has been repeatedly discussed since this time by different authors but very little light has been thrown upon it, although the general correctness of Breithaupt's opinion has been usually accepted. The most recent contribution is that of Köchlin‡ who, while concluding that Breithaupt was right in his general position, failed to obtain material suitable for an accurate determination of the form. He was able to show a certain relation between the crystals examined by himself and the axial ratio deduced from Breithaupt's angles, but his measurements varied widely and only an appeal to a twinning hypothesis sufficed to bring them into partial agreement.

The paper of Köchlin has led us to carry on to completion some work on these minerals undertaken a year or more ago. Our results serve to establish the independent position of polianite beyond all question, and to show that in form it is tetragonal and *isomorphous with cassiterite*, and the allied species of the RO_2 group.

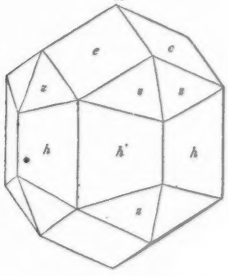
* Trans. Roy. Soc. Edinburgh, xi, 119, 1827; Pogg. Ann., xiv, 204, 1828.

† Lichtes Graumanganerz, Charakt. Mineralsystems. 103, 241, 1823; Pogg., lxi, 191, 1844.

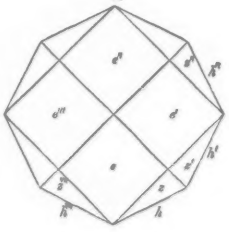
‡ Min. petr. Mitth., ix, 22, 1887.

Of the half dozen specimens in hand, one (A) was especially suited for accurate crystallographic and chemical work (Y. U., 2143). It exposed a crystalline surface consisting of closely compacted composite individuals, and upon this were thickly implanted numbers of small highly modified bead-like crystals with more or less brilliant faces. The relation between these small crystals and the mass of the specimen was not obvious at once, but as soon as the former had been made out it was seen that the composite crystals were identical with the others in form, each one being made up of a multitude of individuals in parallel position. Closer inspection showed also that the apparently simple small crystals were also often composite. The larger crystals were often rhombic in habit and were terminated by a large basal surface formed of the vertices of the closely compacted pyramids. The form of these crystals is shown in figs. 1 and 2.

1.



2



The planes present are:

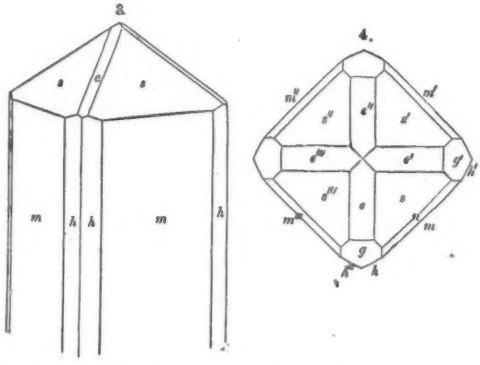
h(210, $\dot{\imath}$-2), e(101, 1-$\dot{\imath}$), z(321, 3-$\frac{3}{2}$), and also the form m(110, I) in traces.

The planes of the prism h are rather rough and uneven; those of e are brilliant but uniformly rounded on either side of the vertical diagonal, showing a tendency to develop into two vicinal pyramidal planes; the planes of the zirconoid z are usually brilliant and give good reflections. Having before us the description of Breithaupt and the apparently confirmatory results of Köchlin, our attention was especially directed at first to the question as to the system to which our crystals belonged and their relation to Breithaupt's form. A large number of measurements consequently were made, some of which are given beyond, but while they showed considerable variation among themselves, more than the character of the faces seemed to justify, they did not conform to the orthorhombic form, although approximating to the angles of Köchlin.

A second specimen in hand (Y. U., 2154) showed a mass of quartzose rock, and in a cavity in it a considerable amount

of a rather open aggregate of manganese dioxide in part developed into distinct prismatic crystals. The mass proved upon examination to be anhydrous MnO_2 with a hardness of 6 to 6·5. This was throughout distinctly crystalline in structure, consisting of minute tetragonal pyramidal and prismatic crystals built up together into parallel position.

The prismatic crystals were in part hollow shells with the termination often gone, but the prism sufficiently preserved to show that the original mineral was without question manganite with its usual prismatic angle of 80°. In others of the crystals the rebuilding process had gone farther with the result of giving a complete tetragonal crystal with the habit shown in figs. 3 and 4.



The planes here present, being referred to the same fundamental form as variety A, are:

m (110, I), h (210, i-2), s (111, 1), n (221, 2), e (101; 1-i), g (201, 2-i).

In consequence of the fact that the crystals are all composite growths the planes were none of them perfectly smooth and simple. The best faces for measurement were those of the pyramid s, though here there is commonly an oscillation with e and sometimes the crystals are much elongated in this zone and rounded over from s to the adjacent s'.

As the fundamental angle for the species the following was accepted from the variety B:

$$s \wedge s' \quad 111 \wedge \bar{1}11 = 57° 56' \quad \text{whence} \quad \overset{1}{c} = 0{\cdot}66467.$$

Two of the other pyramidal angles on the same crystal gave 58° 2′ and 58° 5′. The following angles, measured on crystals from the first specimen, will serve to show the variation mentioned:

					Calc.
hh'	$210 \wedge 120$	36° 12′,	36° 3′,	35° 56′	36° 52′
hh^{vii}	$210 \wedge 2\bar{1}0$	54° 10′,	54° 43′,	54° 50′	53° 8′
ee'	$101 \wedge 011$	46° approx.			46° 5′
zz'	$321 \wedge 231$	19° 58′,	20° 53′,	20° 38′	20° 51′
zz^{vii}	$321 \wedge 3\bar{2}1$	62° 11′,	60° 46′,		61° 35′
zz^{viii}	$321 \wedge 32\bar{1}$	45° 28′,	45° 50′,		45° 18′
zz^{ix}	$321 \wedge 23\bar{1}$	50° 10′,	50° 34′,		50° 22′

All the above angles were measured with a Fuess goniometer with two telescopes. In addition, two subordinate planes n and g were determined by approximate measurements as follows: eg=19°, calc. 19° 26′; sn=18°-20°, calc. 18° 46′.

As shown above the measured angles vary somewhat widely, but when carefully discussed it is found that no better agreement is obtained when an assumption is made that the crystals belong to a system of lower symmetry. On the contrary the best angles lead to the tetragonal system, to which the symmetry in the development and character of the individual planes emphatically conforms. An explanation of the variation of angle is doubtless to be found in the fact stated that the crystals are all composite, and the individuals of which they have been built up are not absolutely in parallel position. A comparison of the angles given with those of Köchlin shows that he must have had crystals resembling figure 1 in hand, in fact he says that for a time he was inclined to consider his crystals as tetragonal. He was unfortunate in his material, for he adds that he was rarely able to use the telescopes of the goniometer. Köchlin's planes referred to our fundamental form are as follows: 310=h, 110=100, 334=e. If, however, the measurements left any doubt as to the system to which polianite should be referred, this is removed by the relation brought out by the above measurements, namely, that polianite is isomorphous with cassiterite and the allied species rutile and zircon. The relations between them are as follows.

		c	ee'	ss'
Cassiterite,	SnO_2	0·6732	46° 28′	58° 19′
Polianite,	MnO_2	0·6647	46° 5′	57° 56′
Rutile,	TiO_2	0·6442	45° 2′	56° 52½′
Zircon,	ZrO_2 / SiO_2	0·6404	44° 50′	56° 40¼′

The interesting group of oxides having the general formula RO_2 thus receives an important addition, a result which was not anticipated when our work was begun but which can occasion no surprise.

The hardness of both specimens of the polianite is 6 to 6·5. The specific gravity of A was found to be 4·992, the mean of three determinations, 4·971 on 0·833 gr., 4·965 on 0·813 gr.,

5·040 on 6·092 gr. The first two determinations were made on a chemical balance the last in a pycnometer. These results, which are somewhat higher than those of Breithaupt, were obtained with great care, the material being first boiled in water for some time to drive off the air. The crystals show perfect cleavage parallel to *m*.

The chemical examination (Penfield) showed that the material was pure MnO_2, free from all but a trace of water. The analytical results are given below together with the analysis of Plattner of the original polianite:

	A.	Ratio.	B.	Plattner.	Ratio.
MnO	80·81	1·138		81·17	1·143
O	18·16	1·135		[18·21]	1·132
Fe_2O_3	·16			·17	
SiO_2	·36				
Insol	·16		trace	·13	
H_2O	·28		trace	·32	
	99·93			100·00	
Loss by ignition	12·44		12·42	12·43	

The ratio of MnO : O is almost exactly 1 : 1 and the mineral is therefore a very pure MnO_2. The material which was analyzed was almost wholly soluble in HCl, leaving a very slight residue 0·16 per cent, the remaining 0·36 per cent SiO_2 separated from the solution by evaporation to dryness.

The method of analysis was as follows: a weighed quantity of material was ignited over the blast lamp till a constant weight was obtained, the MnO_2 being converted into Mn_3O_4. After dissolving the oxide in HCl the Fe_2O_3 and SiO_2 were determined and the solution tested for Ba, Ca and Mg. From the weight of the Mn_3O_4 after deducting Fe_2O_3 and SiO_2 the MnO was calculated. The excess of O over MnO was determined by converting oxalic acid into CO_2 and collecting and weighing the same in potash-bulbs. The H_2O was determined by igniting the mineral in a hard glass tube and collecting the water in a chloride of calcium tube. The chemical identity of B was proved by the fact that it gave only traces of water in a closed tube and lost 12·42 per cent by strong ignition. The ignited oxide was soluble in HCl, and gave traces of SiO_2 after evaporation to dryness.

We purpose in a later article to present some observations upon pyrolusite and the related minerals braunite and hausmannite, especially with reference to the relation of pyrolusite to polianite.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Stalagmometer and its use in quantitative analysis.*—Two years or more ago, Traube observed the markedly greater effect of iso-amyl alcohol, in lowering the height of a capillary column, over that of ethyl alcohol, even when both were diluted with water to the same extent. He based upon this observation a method for estimating the amount of fusel oil in alcoholic liquors, and constructed an instrument, called a capillarimeter, by which the capillary elevation could be easily measured. In a liquid containing twenty per cent of alcohol, one-tenth of a per cent of fusel oil would lower the column a millimeter. As this instrument did not prove convenient in practice, the author adopted a modified method of testing, also founded on the principle of surface tension, consisting simply in counting the number of drops contained in a given volume of the liquid. To facilitate the process, a bulb tube was used, having marks above and below the bulb, the volume between the two marks being known. Below, the tube was bent at right angles, united to a short capillary tube, then bent downward again, terminating in a flat disk having a small hole in the center. This instrument he calls a *stalagmometer*, and by its means drops may be counted with an error of not more than 0·2 of a drop in 100 drops. To use it the alcoholic liquid to be tested is diluted to contain about 20 per cent of alcohol by volume, the stalagmometer is filled with it, the number of drops in the given volume counted and compared with the corresponding number given by pure 20 per cent alcohol. An excess in the former case of 1·6 drops in 100 corresponds to 0·1 per cent fusel oil, of 3·5 drops to 0·2 per cent, etc. Since the maximum error is 0·2 of a drop in 100, as small a quantity as 0·05 per cent of fusel oil can thus be certainly detected. In order to increase the delicacy of the method, the author concentrates the solution as follows: about 300 c. c. of the alcoholic liquor, previously diluted to a 20 per cent strength, is placed in a stoppered separating funnel furnished with a tap, from 110 to 120 grams of pure ammonium sulphate is added and the whole is shaken, until on standing for a minute or two, it separates into two well-defined layers. The upper of these is diluted with water and two-thirds of it distilled off. The distillate is made up to 100 c.c., its density is determined, and after dilution to 20 per cent it is placed in the stalagmometer and the number of drops compared with that obtained with pure alcohol of the same strength. In a series of comparative tests, fusel oil being added to pure alcohol to the extent of 0·05, 0·10, 0·18 and 0·3 per cent respectively, the stalagmometer method gave 0·04, 0·07, 0·18 and 0·26 per cent. In general, the influence of the compound ethers and etherial oils is too

slight to affect the result. But even this influence may be entirely eliminated by previous distillation with an alkali solution.

In subsequent papers TRAUBE has extended this method to the estimation of the strength of ethyl alcohol and of acetic acid, and to the determination of the alcoholic strength of wine, beer and liqueurs. He gives carefully prepared tables of the number of drops given by mixtures of absolute alcohol and water varying by tenths from 0 to 10 per cent by weight, and in temperature by degrees from 10° to 30°; those given by pure water at 15° being 100. At a concentration of 20 per cent, an error of 0·2 drop in 100, corresponds to an error of only 0·1 per cent in the amount of alcohol. The acetic acid table is similar, but its range in temperature is only from 11° to 29° in 2° stages. The results of the method as applied to wine and beer are given and show that it may be relied on within 0·1 per cent, when used on the distillate.—*Ber. Berl. Chem. Ges.*, xx, 2644, 2824, 2829, 2831, Oct., Nov., 1887.

G. F. B.

2. *On Apantlesis; a Separation of the Constituents of a Solution by Rise of Temperature.*—Having observed that on several occasions the upper part of an alcohol thermometer column, after having slowly risen from a considerable contraction, was colorless, and that no deposit of the coloring matter (probably cochineal) had taken place, MALLET was led to make further experiments in this direction. It seemed as if the colorless alcohol had by its expansion separated itself from a still perfect solution left behind. The solutions used were partly aqueous partly alcoholic, of several colloid substances, starch, tannin, caramel, albumen and gelatin. Each solution was placed in a flask of about half a liter capacity, surrounded with ice, the mouth of the flask being closed with a cork carrying a glass tube about 4^{mm} in diameter and 15 or 20^{cm} long, having a glass tap near its middle point The ice being removed the liquid was allowed to rise in temperature until the column, originally a centimeter or two below the tap, was as much above it. The tap was now closed and the liquid above it submitted to examination in comparison with an equal volume of the original solution. In all cases the liquid above the tap contained a less amount of material in solution, in some cases very notably less; while in two or three cases there was practically none. As all the solutions were carefully filtered at the outset, there could have been no settling of particles. The conditions influencing the result seem to be: first the proportion of the colloid solid in solution; and second, the time occupied in the rise of temperature. The author has given the name *apantlesis* to this phenomenon, signifying a draining away of some of the molecules of the solvent from those of the colloid while the solution was undergoing expansion. —*Chem. News*, lvi, 146, Oct., 1887. G. F. B.

3. *On the Properties of Fluorine.*—MOISSAN has published in full his investigation upon the isolation of fluorine, made in Debray's laboratory. As we have already noticed his methods*

*See this Journal for March, 1887, p. 236.

we give here his conclusions on the properties of fluorine. It is a colorless gas, having an odor recalling that of hypochlorous acid. It combines directly with hydrogen even in the dark and without the aid of heat; being the only instance where two gases unite directly without the aid of external energy. Sulphur, selenium and tellurium are inflamed on contact with it. Phosphorus takes fire in it, and yields a mixture of oxyfluoride and of fluorides of phosphorus. Iodine burns in it with a pale flame; arsenic and antimony unite with it with incandescence. Crystallized silicon, cold, burns brilliantly in it, yielding the gaseous fluoride. Adamantine boron also burns in it, but with more difficulty. Potassium and sodium become incandescent when cold, iron and manganese when slightly heated. Mercury absorbs it completely, but gold and platinum are not attacked by it at ordinary temperatures. Melted potassium chloride and iodide are at once attacked by it, the chlorine and iodine being set free, the latter in the form of crystals. Water is decomposed by it in the cold, forming hydrogen fluoride and setting free ozonized oxygen. Carbon disulphide is at once inflamed by fluorine; and when this gas is received in carbon tetrachloride, it produces a continual evolution of chlorine. Organic bodies containing hydrogen are violently attacked by fluorine. A fragment of cork is carbonized at once and ignited if placed in front of the evolution tube. Alcohol, ether, benzene, turpentine, petroleum take fire on contact with this gas. In a word, fluorine appears justly to occupy the place hitherto assigned to it at the head of the group of halogens, as a substance whose activity surpasses that of any other element.—*Ann. Chim. Phys.*, VI, xii, 472–538, Dec., 1887.

G. F. B.

4. *On Oxygen Carriers.*—Lothar Meyer has made a series of experiments to test the alleged function of certain substances as oxygen carriers. Oxygen and sulphur dioxide gases were passed for four hours, as a rule, through solutions of the salts to be tested, of known concentration, heated in flasks placed on the water bath. After expelling the excess of sulphur dioxide by carbon dioxide gas, the sulphuric acid which had been formed in the solution by oxidation was determined by analysis. The results confirmed the alleged fact. The most active salt was manganous sulphate, $MnSO_4 . (H_2O)_5$, 2·404 grams of which dissolved in 200 c.c. of water, produced five times as much sulphuric acid as the salt itself contained; i. e., $(H_2SO_4)_5$ for $MnSO_4$. Manganous chloride was also active and produced 4·3 molecules H_2SO_4 in the same time. The salts of copper, iron, cobalt, nickel, zinc, cadmium and magnesium were also active but in a less degree; while thallium and potassium salts gave no result. The author attributes this action to alternate oxidation and reduction, since those metals are the most active which pass most readily from one stage of oxidation to another.—*Ber. Berl. Chem. Ges.*, xx, 3058, Nov., 1887. G. F. B.

5. *On the Atomic Weight of Zinc.*—Reynolds and Ramsay by measuring directly the hydrogen set free by the solution of a

known weight of zinc in acid have obtained the value 65·50 for the atomic weight of this metal. This method has the advantage of being independent of any other atomic weights.—*J. Chem. Soc.*, li, 854, Dec., 1887. G. F. B.

6. *A Text-book of Inorganic Chemistry.*—By Prof. VICTOR VON RICHTER. Authorized translation by Prof. EDGAR F. SMITH. Third American from the fifth German edition. 12mo, pp. xvi, 428. Philadelphia, 1887. (P. Blakiston, Son & Co.)—This book has been for some time in the hands of American readers, and the demand for a third edition is evidence that it has been well received. In the thirty pages of introduction, the author sketches the province of chemistry, its symbols and formulas, the principles of energy, and the conservation of energy, the energy-relations of chemical changes and crystallography. The elements are then taken up, beginning with hydrogen, and the philosophy of chemistry is gradually worked in as it is required. For instance, after the hydrogen compounds of the halogens, the law of definite proportions, the atomic theory, and the volume relations of the elements are discussed. A hundred pages later come atomic and molecular values, valence and chemical structure; and at the close of the non-metallic groups, the periodic system is considered. An excellent feature of the book is the considerable space given to the energy relations of chemical changes, particularly to heat relations. The distinction drawn by Berthelot between epothermic and endothermic reactions is emphasized and the great importance of such reactions as $H+Cl=HCl+22000$ cal. and $H+I=HI-7000$ cal. is maintained firmly. We are glad to note an extension of this thermal discussion, as well as of other physical relations, intimately associated with chemistry, in this third edition. The section on Mendelejeff's periodic system of the elements is carefully written and gives an excellent account of this remarkable classification. In an appendix is given the heat of formation of the most important metallic compounds according to J. Thomsen. Dr. Smith has performed well the part of a translator, although a want of perfect smoothness in flow sometimes betrays the difficulties he has had to contend with. The printing and mechanical work are good, but the woodcuts seem hardly up to the standard of the rest of the book. G. F. B.

7. *A Manual of Analytical Chemistry;* by JOHN MUTER. Third edition. 200 pp. Philadelphia, 1887. (P. Blakiston, Son & Co.).—Muter's Analytical Chemistry appears in the third edition in compact form but enlarged in scope. Of the host of works of its kind, dealing simply with the outlines of the subject, it is one of the fullest and best.

8. *A new instrument for measuring heat.*—Prof. WEBER at a meeting of the Helvetii Society of Sciences described the following very sensitive micro-radiometer. One arm of a Wheatstone bridge is formed by a thin tube, which is filled in its middle part with mercury, and at its ends, for about 5^{mm}, with a solution of zinc sulphate. To each end of the tube is fitted a metallic case, one side of which consists of a plate of rock salt. This case is

filled with air, which dilates under the influence of radiation, forces back the zinc sulphate solution in the tube, and thus greatly increases the electrical resistance on that side. The apparatus is made symmetrical to eliminate variations of pressure and temperature. This radiometer will indicate one hundred millionth of a degree. The moon's radiation gives a galvanometer deflection of five divisions.—*Nature*, p. 157, Dec. 15, 1887. J. T.

9. *Velocity of Sound.*—At a meeting of the Physical Society, London, Nov. 12, Prof. A. W. RUCKER exhibited an apparatus for determining the velocity of sound on the principle employed by Fizeau for measuring the velocity of light. "A vibrating reed is used as the source of sound and a sensitive flame as the receiver. A long U-shaped tube has its two ends placed near and parallel to the plane of a perforated disc, which is capable of rotating about an axis perpendicular to its own plane. The reed and sensitive flame occupy similar positions on the opposite side of the disc. On rotating the disc the sensitive flame flares or is quiescent according as the time taken to travel the length of the tube is an even or an odd multiple of $\frac{T}{2n}$, where T is the time of one revolution and n the number of holes in the disc."—*Nature*, p. 119, Dec. 1, 1887. J. T.

10. *On the transmission of power by alternating electrical currents.*—Mr. T. H. BLAKESLEY, in a communication to the Physical Society, London, Nov. 12, discussed the relative efficiency of the transmission of power by direct and by alternating dynamos, and concludes that the ratio of power to weight is much greater for a direct than an alternating current motor. The author considers this a great drawback to the employment of the latter. He also showed that by placing a condenser between the terminals of the recipient machine a greater current could be passed through the receiver than that in the generator and line.—*Nature*, p. 119, Dec. 1, 1887. J. T.

11. *Measurement of Electromotive Forces.*—Sir WILLIAM THOMSON has employed his new deciampere balance to the determination of the electromotive force of a Clark cell. The result obtained was 1·436 volts at 15° C. The result obtained by Lord Rayleigh was 1·435 at 15° C.—*Phil. Mag.*, p. 514, Dec., 1887. J. T.

12. *Influence of Magnetism on the Thermo-electric behavior of Bismuth.*—Dr. GIOVANNI PIETRO GRIMALDI shows that the thermo-electric behavior of bismuth in relation to copper is weakened by magnetism. The diminution of the electromotive force was about $\frac{1}{30}$ —, and seemed to be of the same order of magnitude as the variations in electrical resistance investigated by Righi.—*Rendiconti della R. Accademia dei Lincei*, Feb., 1887. J. T.

13. *Coincidences between lines of different Spectra.*—The difficulty of deciding upon the existence of a metal, like cerium, in the sun, is very great, since, on account of the number of lines in the spectrum of the metal, the probability of many of its lines coinciding in position with lines in the solar spectrum is very great.

This coincidence may be only accidental. Schuster has employed a criterion which depends upon a supposed harmonic relation between the lines of a spectrum. Mr. LOVE employs a method of discrimination based upon the law of error. The differences between the wave-length of the lines compared are arranged in groups, each group containing those observations, the errors of which lie within certain narrow limits. The number of observations in each group is then plotted as an ordinate of a curve, the average error of the group being the abscissa. This curve is then compared with the law of error $y = a\varepsilon^{-c^2x^2}$. To show the applicability of the method, various curves are given, notably those due to observations on cerium and the spectrum of water.—*Phil. Mag.*, Jan. 1888, pp. 1–6. J. T.

14. *Influence of thickness and luminosity of light-producing layers, upon the character of spectra.*—Certain authors, notably Wüllner in his work on Experimental Physics, maintain that line and banded spectra can be made interchangeable by modifying the pressure of the gases or increasing or diminishing the extent of the layer which is made luminous by electrical discharges. EBERT, by a series of experiments, is brought to the conclusion that the experiments adduced by Wüllner and other writers, merely show that banded spectra can be reduced to line spectra by diminishing the illumination. No increase or diminution of density or thickness of luminous layers can account for the change of one class of spectra with another. This change must be rather attributed to a change in the molecular grouping.—*Ann. der Physik und Chemie*, No. 1, 1888. J. T.

15. *On the measurement of force of gravitation.*—The determination of the force of gravitation by means of a pendulum, it is well-known, requires great skill and the employment of many corrections. In a note presented to the Academy of Science, M. DEFFORGES shows that we can eliminate the effects of the support and that due to the curvature of the knife-edges by making use of two pendulums which oscillate within the same limits of amplitude upon the same support and the same knife edges. These pendulums have the same weight, but are of different lengths. Their centers of gravity are similarly placed in regard to the sides of the knife-edges.—*Comptes Rendus*, Jan. 9, 1888, p. 126. J. T.

16. *Influence of temperature on Magnetization.*—In studying this subject, M. Ledeboer made use of the novel plan of placing the bars of iron or steel in platinum spirals which were heated to suitable temperatures by means of an electrical current. The soft iron examined by M. Ledeboer, lost its magnetism entirely at 770° C. and had barely any at 750° C. In a recent study upon the specific heat of iron at high temperatures, M. Pionchon has shown that iron undergoes a change of state between 660° and 720°. Iron loses its magnetic properties also between 680° and 770°. M. Ledeboer calls attention to this remarkable fact.—*Comptes Rendus*, Jan. 9, 1888, p. 129. J. T.

II. Geology and Mineralogy.

1. *Note respecting the term Agnotozoic.*—In the closing portion of the article in the November number of this Journal entitled "Is there a Huronian Group?" Prof. R. D. Irving has advocated the adoption of the term "Agnotozoic" as a comprehensive designation for the fragmental rocks which lie between the base of the Cambrian formations and the summit of the Archæan crystallines, and has credited me with the authorship of the term and the early advocacy of the desirableness of a distinct name for these formations. Concerning this I wish to file a disclaimer; not that I do not fully concur with Professor Irving in this advocacy, for I do most cordially, nor because I suppose it to be a matter of consequence to Professor Irving, since I know that he holds all questions of priority or proprietorship in nomenclature in little esteem, if not in light contempt. I wish to file the disclaimer not because of this special case but out of respect for a general principle in nomenclature, which I hope to see adopted to the displacement of a purely technical and indiscriminative application of the law of priority. I hold that nomenclature of the class in question should rest, not with some individual, who, standing by and looking upon the work of others, may see, perchance before they do, whereunto their labors are growing; nor with some one, who, on the basis of superficial observation and hasty conjecture, throws out first to the world a tentative nomenclature, leaving it to the future and to the labors of others to justify or reject; but on the contrary, I hold it should rest with the patient and thoroughgoing investigator, who by careful and comprehensive study develops an adequate basis for nomenclature, properly sanctioned by a broad and trustworthy array of facts. I have been in some senses a student of the formations to be embraced under the proposed term, but in no such sense as to give me the right of nomenclature under this principle. If, therefore, this term shall be adopted, as I sincerely trust it may, I earnestly desire that it shall stand to the credit of some one who has had a larger part in the actual development of the facts upon which its adoption must rest, among whom I know of no one who has contributed more than Professor Irving.

If it were needful I could take refuge behind the fact that although I have used the term in correspondence, conversation, discussion and other informal ways for the past two years, more or less, I have nowhere formally proposed it in a scientific publication; *but it is the principle of just nomenclature*, and not a specific result in this case that gives purpose to this note.

On this principle, as well as technically also, the name Keweenawian or Keweenawan should be credited to Major T. B. Brooks, or to Messrs. Brooks and Pumpelly jointly, since it was through their labors that there was first presented a sufficient body of specific facts, correctly interpreted, to justify the adoption of the term by those who accept the distinctness of that formation. The

term Keweenian was not only proposed subsequently, but rested upon no extensive, careful and specific field investigation on the part of the author, which, on the principle above indicated, is the necessary sanction of acceptable nomenclature.

T. C. CHAMBERLIN.

University of Wisconsin, Nov. 15, 1887.

2. *Contributions to the Paleontology of Brazil*, comprising *descriptions of Cretaceous Invertebrate fossils, mainly from the Provinces of Sergipe, Pernambuco, Para and Bahia;* by CHARLES A. WHITE. From vol. vii of Arch. do Mus. Nacional do Rio de Janeiro. 274 pp. 4to, with 28 plates.—The Cretaceous fossils described by Dr. White were collected by the Geological Survey of Brazil while it was under the charge of Prof. C. F. Hartt, and were sent to Dr. White for description by Mr. Orville A. Derby. The rocks occupy a coast region from the mouth of the Amazon southward for eighteen degrees of latitude. The fossils include many Cretaceous types, but it is remarkable, says Dr. White, that the conchifers, and especially the gasteropods, have little in common with those of North America. The fauna as a whole seems to be more nearly related to the Cretaceous of southern India than to any other that has been investigated—a fact apparently indicating that part of the peculiarities may be due to the equatorial temperature. The fauna is spoken of as having also a Tertiary feature in the presence of species of Fusus, Murex, Phorus, etc. The most of the species are new. They are beautifully figured on the 28 lithographic plates. The Cephalopods are referred to thirteen species and among them there is one Helicoceras. The Ammonites include *Ammonites Hopkinsi* of Forbes which agrees well with Stoliczka's figures of a specimen from India, and *A. planulatus* Sowerby, which also occurs in India, or a species very near it. Plates 27 and 28 are devoted to the Echinoderms, of which there are 15 species.

3. *Arkansas Geological Survey.*—The Geological Survey of Arkansas, under the charge of Dr. Branner, is going forward with vigor, through the aid chiefly of volunteer assistants. A report on Clarke County by Mr. R. T. Hill, with a geological map, will be finished this season, and another, on Washington County, by Dr. F. W. Symonds. Work is going forward also on the coal fields by Arthur Winslow.

4. *Fossils of Littleton, New Hampshire.*—The Littleton fossils were referred to the Niagara group by Prof. C. H. Hitchcock, in 1884, in a paper on Geological Sections crossing New Hampshire and Vermont, in the Bulletin of the American Museum of Natural History of New York.

5. *Palæolithic Man in Northwest Middlesex:* The evidence of his existence and the physical conditions under which he lived in Ealing and its neighbourhood, illustrated by the condition and culture presented by certain existing savages; by JOHN ALLEN BROWN, F.G.S. 228 pp., 8vo, with frontispiece and 8 plates. London, 1887. [Macmillan & Co.]—This interesting volume is

illustrated by figures of flint implements of various forms from the vicinity of Ealing. To these are added representations of similar implements from other beds of like age, and also from those now in use among existing men, as the Esquimaux, Australians, Fuegians and others; and the frontispiece represents, in an ideal picture, the method of chipping the flint into arrow-heads and other forms.

6. *On the Organization of the Fossil Plants of the Coal Measures.* Part XIII; by W. C. WILLIAMSON, LL.D., F.R.S. Philosophical Transactions of the Royal Society of London, vol. clxxviii, 1887.—Nearly six years have elapsed since the appearance in 1882 of the twelfth of this remarkable series of memoirs which, prior to that date had been issued at the rate of one every year since their commencement in 1871. The casual observer might infer from this that the powers of the distinguished author were failing, but when we learn what other work he has done during this interval we cannot wonder that the special investigations which are recorded in these memoirs have been somewhat interrupted.

One would suppose that the preparation of his splendid Monograph on the Morphology and Histology of Stigmaria ficoides, published by the Palæontographical Society in 1887, might have occupied the whole of this time, not to speak of his work for the British Association, as president of the Geological Section and on committees for the investigation of the Tertiary flora of the north of Ireland and of that of the Halifax coal measures, which, with his other collateral work aggregate a score or more of important contributions from his pen to the science of fossil plants during the past five years.

The present memoir deals with some new phases of his two genera, Heterangium and Kaloxylon, which he established in Part IV of this series in 1873. The most important fact now brought out is that these plants, while possessing most of the points of structure essential to ferns, have, nevertheless, at the proper period of their growth, a distinct exogenous zone with a cambium layer separating the xylem from the phloem. Relative to the systematic position of these remarkable plants he is only certain that they have no representatives among living plants. He suggests the possibility of their being the generalized ancestors of both ferns and cycads, and cites Stangeria with its fern-like dichotomous nervation linking these two families of plants by their foliage in a manner similar to that in which these extinct forms link them by their internal structure. L. F. W.

7. *Catalogue of the Fossil Mammalia in the British Museum;* by RICHARD LYDEKKER, F.G.S., part V, London, 1887.—This Part finishes the Catalogue. It includes the group Tillodontia, and the Orders Sirenia, Cetacea, Edentata, Marsupialia and Monotremata, together with miscellaneous notices in a supplement. The critical notes in this Catalogue give it very great value.

8. *The Geological Evidences of Evolution;* by ANGELO HEILPRIN, Prof. Invert. Pal. and curator Acad. Nat. Sci. Philad.,

100 pp., 12mo., Philadelphia, 1888.—Prof. Heilprin has here presented a brief review of the more prominent facts in paleontology supporting the theory of evolution. It is a carefully prepared statement made with little technicality, and illustrated by good figures.

9. *Kilauea.*—In the paper by Mr. J. S. Emerson, in volume xxxiii, page 90, the words "Little Beggar," in line 27 from the top should be "New Lake."

10. *Allgemeine und chemische Geologie von* JUSTUS ROTH. 2nd volume, third part closing the volume. Crystalline Schists and Sedimentary Rocks.—The author opens his chapter on the Crystalline Schists with the remark that in his opinion, the schists are Plutonic, or the material of the earth's first-cooled crust. He has thus got back to old an error, through the help of the new facts put forward by Dr. Lehmann, just at a time when opposing facts are fast multiplying. The value of the work, however, is not much affected by the theoretical assumption, except that he cites statements that coincide with the view, and omits the facts that disagree with it. The rocks are described with fullness, many chemical analyses are given, and long lists of localities are added. Quartzite is placed rightly both under "crystalline schists" and "Neptunian rocks;" but among his *North American* localities those of the Taconic region of western New England are *omitted;* evidently because the associated mica schists of Western Massachusetts, alternating in some places with the quartzite, would throw them with the "Plutonic," and yet a Lower Paleozoic age is claimed for them, which puts the author in suspense.

11. *Mineral Resources of the United States.*—Calendar year 1886. DAVID T. DAY, Chief of Division of Mining Statistics and Technology. 813 pp. 8vo. Washington, 1887, (U. S. Geological Survey, J. W. Powell in charge). This fourth volume of the series of reports on the Mineral resources of this country, appears with commendable promptness, reflecting credit in this respect as in others upon the editor, Mr. David T. Day. Its scope is similar to that of its predecessor, and like them it contains an immense amount of valuable practical and scientific information not to be obtained elsewhere. A large part of the space is given to detailed discussions in regard to the important metals, fuels, building stones, etc., but there is also considerable fresh information as to the rarer substances of less economic value.

12. *Native Platinum from Canada.*—Mr. G. C. HOFFMANN, of the Canada Geological Survey, has contributed a series of analyses of native platinum from Granite Creek, a branch of the Tulameen River in British Columbia. The specimen in hand consisted of 98 per cent platinum with a little gold and pyrite; the specific gravity was found to be 16·656 after removing the foreign matter. It was separated into a magnetic portion (A), 37·88 per cent, with G.=16·095, and a non-magnetic portion (B) with G.= 17·017. The mean analyses gave:

	Pt	Pd	Rd	Ir	Cu	Fe	Iridosmine	Chromite
A. *Magnetic,*	78·43	0·09	1·70	1·04	3·89	9·78	3·77	1·27= 99·97
B. *Non-magnetic,*	68·19	0·26	3·10	1·21	3·09	7·87	14·62	1·95=100·29

The magnetic portion was distinctly magneti-polar, but it was not found to contain appreciably more iron than the others, although that might have been anticipated.—*Trans. Roy. Soc. Canada*, 1887.

13. *The Shepard Collection of Minerals.*—The very large and valuable collection of minerals and meteorites belonging to the late Prof. Charles U. Shepard, has been generously given, by his son, Dr. Charles U. Shepard, to Amherst College. The estimated value of the collection is ten thousand dollars.

14. *Natural Gas.*—Supplement of December 30, of the American Manufacturer and Iron World of Pittsburg, contains valuable papers, both geological and economical, on Natural Gas, by the best American writers on the subject, C. A. Ashburner and John F. Carll, of the Pennsylvania Geological Survey, with a map of western Pennsylvania, also of Kansas, and by Dr. A. J. Phinney, of Indiana, with a map of the Indiana gas field, and other notes on the subject.

III. Botany.

1. *Respiratory Organs of Plants.*—Ludwig Jost of Strassburg communicates to Botanische Zeitung, Sept., 1887, some interesting facts concerning organs of peculiar shape found on the roots of certain palms, and their allies, and a few other plants. These organs are outgrowths from roots, they point upward into the air, and are generally characterized by having a swollen portion conspicuously different from the rest. Experimental study indicates that these organs, like stomata and lenticels, are of use in the aëration of the plant. Jost suggests as a name for this group of organs, *pneumatodes.*

Among the possible cases alluded to by him but dismissed with hardly more than a word, is that of the enormous swellings on the roots of our Southern Cypress, *Taxodium distichum.* Many years ago, Professor Shaler of Harvard stated to the present writer that he believed these excrescences of the Cypress of the South to be related in some way to the aëration of the trees, since he had observed that where these had been submerged for a time by an overflow, the plants suffered and after a while died. In a recent paper in the publications of the Museum of Comp. Zool. at Cambridge, Professor Shaler has given his views in detail, making out a strong case; so that we can feel little hesitation in referring these extraordinary swellings on Taxodium to Jost's new class of *Pneumatodes.* G. L. G.

2. *On a Combination of the Auxanometer with the Clinostat.*—At the writer's suggestion, Albrecht, the well-known mechanician at Tübingen, has constructed a simple form of Auxanom-

eter which can be well employed as a serviceable Clinostat. In addition to the strong axis which carries the equipment of the ordinary Clinostat, there is a smaller spindle driven by the same machinery and at such rates of speed as may be wished. Upon the latter spindle, the common form of registering drum is carried with absolute steadiness. Although, on general principles, one must view with more or less distrust an apparatus aiming to reach two ends so widely diverse as the two just mentioned, the present appliance has thus far worked satisfactorily. But for ordinary use in the class room, it is inferior as an auxanometer to either of the two simple and excellent ones figured and described in the Botanical Gazette by Professors Bumpus and Barnes.

G. L. G.

3. *Die natürlichen Pflanzenfamilien*, von A. Engler und K. Prantl. Leipzig, 1887. (Now publishing in parts of which 12 have already been received).—The first number of this important work and the promise given by it were noticed in this Journal last summer. The numbers which have since come to hand redeem this promise in the most satisfactory manner. The text exhibits care in its preparation even down to the minute treatment of the economic plants, and, although the parts are of unequal merit, all are of a high order, placing the work in the front rank. The illustrations are excellent throughout, and are lavishly used. Serial publications demand from the recipients of the successive parts a fair degree of patience, since in most cases, the separate articles come to the reader in a fragmentary form. Until the disjecta membra are all before one, it is difficult to tell whether they can be united to form a symmetrical structure: everything depends upon the skill in editing and the sense of proportion possessed by the editors. To them belongs the ungracious task of contracting lengthy contributions and, more rarely, of suggesting increase in volume. From all that appears in the present publication, up to the present time, the editors have performed their work with great judgment. Thus far the chief burden has fallen on Professor Engler. A mere enumeration of the leading contributions is all that can be justly given at this early stage in the progress of the publication. Professor Drude has finished the Palms in 93 pages, with seven pages additional given to the Cyclanths; Haeckel carries the Grasses through 96 pages, with more to come; Engler has given 91 pages to Liliaceae; Gymnospermae were treated of in 127 pages by the lamented Eichler, whose notes have received some additions from both the editors. Other contributions are from Pax, Hieronymus and Wittmack. In the twelve numbers received, consisting of about six hundred pages, there are 421 illustrations containing about two thousand single figures.

Such a work is of the highest value to teachers of botany and ought even in its German form to command a large list of subscribers in this country. It is sincerely to be hoped that an English translation may be early undertaken. G. L. G.

4. *Botanical Necrology* of the year 1887, by Dr. GRAY: his last work for this Journal.—The first two names in the American list belong rather to the obituaries of the preceding year.

W. E. TOLMIE died in British Columbia, near the close of 1886, at an advanced age. A brief notice of his life and services to botany will be found in this Journal, vol. xxxiii, p. 244. To him was dedicated by Torrey and Gray, the Saxifrageous, genus, *Tolmiea*, a native of the country in which his life was passed.

JOHN GOLDIE, who was born near Maybole in Ayrshire, March 21, 1793, died at Ayr, Ontario, Canada, where he had long resided, in June, 1886, in his ninety-fourth year. From materials communicated by the family, a biography was published in the Botanical Gazette for October, 1886; but his name was accidentally omitted from our necrology of that year. Mr. Goldie was educated as a gardener; and most Scotch gardeners in those days were botanists. From the Glasgow Botanic Garden, then in charge of Sir Wm. Hooker, he came to America for botanical exploration in the year 1817. The interesting particulars of this expedition are entirely omitted from the biography mentioned above, and were probably unknown to the writer. They are here given in an abstract from his "Description of some new and rare Plants discovered in Canada in the year 1819," published in the Edinburgh Philosophical Journal, vol. vi, April, 1822. "Having had for many years a great desire to visit North America, chiefly with a view to examine and collect some of its vegetable productions, I contrived in 1817 to obtain as much money as would just pay my passage there, leaving when this was done but a very small surplus." He sailed from Leith to Halifax, went to Quebec, whence he despatched his collections of living roots and dried plants in a vessel bound for Greenock, "but never heard of them afterwards." At Montreal, he found Pursh, who advised him to explore the northwest country and promised to obtain for him permission to accompany the traders going to that region the following spring. "I travelled on foot to Albany, thence proceeded by water to New York. . . . . I explored the eastern part of New Jersey, a country which though barren and little inhabited, yet presents many rarities to the botanist, and gave me more gratification than any part of America that I have seen. At a place called Quaker's Bridge, I gathered some most interesting plants, and having accumulated as large a load as my back would carry, I took my journey to Philadelphia,"—thence to New York, whence a ship was about to sail to Scotland, "and, having again committed my treasures to the deep, I had again, as the first time, the disappointment of never obtaining any intelligence whatever of them. My finances being now extremely low and winter having commenced, I hardly knew what to do; but, after some delay, went up to the Mohawk river, where I found employment that season as school-master,"—thence in the spring to Montreal, and failing to make the connections necessary to reaching the northwest district, he "took to the spade" all summer

long, except two days in the week which he devoted to botanizing. "In the autumn I shipped my collection of plants, and in two months had the mortification to learn that the vessel was totally wrecked in the St. Lawrence. During the next winter I did little, except employing myself with such skill as I was able in designing some flower-pieces, for which I got a trifle. Early the following spring I commenced labor again, and by the beginning of June, had amassed about 50 dollars, which, with as much more borrowed from a friend, formed my stock of money for the next summer's tour. I started in the beginning of June from Montreal, and passing through Kingston went to New York [meaning the State, evidently], to which, after an excursion to Lake Simcoe, I returned; then visited the Falls of Niagara and Fort Erie, and crossed over to the United States, keeping along the eastern side of Lake Erie," he crossed over to Pittsburgh, back by way of Olean, Onondago, and Sackett's Harbor to Montreal, and thence safely home to Scotland, "the plants I carried with myself being the whole that I saved out of the produce of nearly three years spent in botanical researches." Hard lines these and in those days for collecting botanists,—which those who "stay at home at ease" do not appreciate.

Among the fruits garnered in Goldie's paper of 16 pages, are *Primula pusilla*, *Xylosteon oblongifolium*, *Viola Selkirkii* (the name given by Pursh), *Drosera linearis*, *Stellaria longipes*, *Ranunculus rhomboideus*, *Corydalis* [*Dicentra*] *Canadensis*, *Habenaria macrophylla* [which is the *H. orbiculata*, Goldie and Hooker having unfortunately taken the smaller round-leaved species for that], and *Aspidium Goldianum*, that noble fern, named and about that time figured by W. J. Hooker. The latter's name has mistakenly been affixed to one or two of these species. But, although he doubtless examined the plants, and probably drew up the Latin characters and contributed the figures on the plate, there is no mention of his name in Goldie's paper except for the fern which well commemorates Goldie's name.

In the year 1824, he was commissioned to take charge of a cargo of living plants sent by the Edinburgh Botanic Garden to that of St. Peterburgh. On his return he went into the nursery business in his native country, during which he revisited Russia, bringing home, it is said, *Picea Pichta* and the double-flowered *Pæonia tenuifolia*. Then, with a laudable wish to better the prospects of his family, in 1844 he transported his home from the Scotch to the Canadian Ayr, in the province of Ontario, where he flourished and prospered for over thirty years of green old age, and died in the midst of numerous and prosperous children, grand-children, and great grand-children.

Albert Kellogg died at Alameda, California, on the 31st of March last, at the age of 74 years. We have few particulars of his life. It is said that he was born at New Hartford, Connecticut, and he had doubtless entered the medical profession before he went to California. He was one of the founders of the Cali-

fornia Academy of Natural Sciences; and we may expect from that institution a full biography. As well as we can make out, Dr. Kellogg emigrated to California thirty-four or thirty-five years ago; and he resided at San Francisco for all the rest of his life. Upon the first page of the first volume of the Proceedings of that institution, under the date of September 4, 1854, we find that Dr. Kellogg was in the chair, and that he exhibited specimens and a drawing of a plant found on the shore of the bay. He drew plants remarkably well and devoted very much time to this work, even to the last. Unfortunately the rude wood cuts which largely illustrate his many papers in the Proceedings of the California Academy give a poor idea of his pictorial skill; while his want of books and of botanical resources greatly derogated from the value and authority of his determinations and descriptions of the very many plants which he published throughout a long series of years. But he did what he could, in his own way, and has left an indelible mark upon the botany of the Pacific coast. He was a man of the utmost simplicity of life and character, a most amiable, gentle and worthy soul. Dr. Torrey dedicated to him the genus *Kelloggia*, appropriately founded on a modest but quite peculiar Californian plant.

William Boott died in Boston, May 16th. He was born in that city on the 15th of June; 1805, consequently he had almost reached the age of 82. He was a younger brother of Dr. Francis Boott, of London, but born in Boston, who is still affectionately remembered by a few of the oldest surviving naturalists. William Boott was educated at Exeter Academy and Harvard University; but his health suffered and he was obliged to leave college before graduation. He traveled in Spain and other parts of the Continent, and studied medicine in Dublin and in Paris; but he did not complete his medical education. Returning to his native country, he lived a quiet and retired life, never marrying, nor taking any of the positions to which he might have aspired. But his excellent talents were sought by one of the western railway companies, to which for many years he devoted a portion of his time. His tastes and his accomplishments in early and middle life were literary, especially linguistic. Probably he took up botany at the instigation of his brother, and with the desire of helping him to the Carices of this country when Dr. Boott began the study of this vast genus, of which he became the illustrator and the highest authority; and William Boott, by a kind of *noblesse oblige*, after his brother's death, specially devoted himself to their study. His only publication is a short Caricological paper. But he studied other groups with great care and critical acumen, especially *Isoetes*, Grasses, and some tribes of *Cyperaceæ*. His health was delicate, but his tall and gaunt form seemed quite unaffected by inclement weather, which he braved to the last, with scant protection. A keen botanist, a most amiable man and trustworthy friend, he is greatly missed at the Cambridge Herbarium, to which he presented his botanical library and collections.

EZRA MICHENER, a physician, of Chester County, Pennsylvania, born November 24, 1794, died June 25, 1887, in his 93d year. He may have derived from Schweinitz his predilection for Fungi, which he cultivated at a time when few botanists of this country knew or cared for them. A genus of Fungi bears the name of this pioneer collector.

HENRY WILLIAM RAVENEL, who was born in Berkeley District, South Carolina, May 19, 1814, died at Aiken, in that State—where he had long resided—on the 17th of July last. When we first knew this kindly and excellent man, he was a planter, upon an inherited estate in St. John's parish, a keen phanerogamous botanist, and a prized correspondent. About 30 years ago he removed to Aiken, in a higher and drier part of the State, now celebrated as a winter health resort. About this time the Rev. Dr. Curtis was well engaged in his notable Mycological career, and Mr. Ravenel was his most zealous follower. So that it is among the Mycologists that his name is most widely known at home and abroad. He published five volumes of *Fungi Carolini-ani Exsiccati*, the sets of which are now rare and very valuable, and in later years he largely contributed the principal materials to the similar *Fungi Americani Exsiccati*, edited by Cooke, of London, in five centuries. He was for many years the botanist of the State Board of Agriculture, and also an agricultural editor. In 1859 he was joined to an U. S. Commission to examine into the cause of the cattle disease then prevalent in Texas. Deafness of many years' standing secluded him much from the world at large, and even from the social circles which he was most fitted to adorn. "The war swept away nearly all of his property"—we recall to mind a touching letter of adieu, when the secession of his State took place, and his hopeful prospects in that connection—"but he met his adversities with Christian fortitude and courage, doing his duty faithfully to the end." A good number of species bear his name, as well as the very peculiar genus of Uredinei, *Ravenelia*. In the Botanical Gazette for August last is an appreciative notice of his life by Dr. Farlow, to which is appended a list of eighteen papers which he published relating to various departments of botany.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Hann's Meteorological Atlas.*—Twelve sheets of the new edition of Berghaus's Physical Atlas are devoted to meteorology under the editorship of Dr. Hann, of Vienna. These may be purchased separately, and if kept unbound they will be found extremely useful as study- and lecture-charts for classes of moderate size, as well as invaluable for reference in all matters of geographic meteorology. The series of maps is remarkably full, including isotherms and isobars, with winds, where well enough known, for the year, January and July; thermic isanomals for the same period; Supan's chart of equal annual variations of temperature;

Buchan's chart of equal diurnal variations of pressure; special annual and seasonal temperature charts for Europe, the United States and the Arctic regions; a rain map of the world, with Loomis's data on a new projection; and a chart by Köppen of the distribution of rain throughout the year. Besides all these, there are several novel maps of a more physical nature; isotherms for Europe in warm (1880) and cold (1879) Decembers, with corresponding isobars in explanation of these weather-anomalies; Köppen's tracks of low-pressure areas over the North Atlantic and adjacent lands; examples of ordinary cyclonic storms in Europe and their accompanying fœhn, siroceo and bora winds, and so on. These latter are especially welcome as aids in calling attention to actual atmospheric phenomena as shown on synoptic charts, in contrast with those more statistical matters in which individual occurrences are lost sight of or concealed by averaging. Tracks of thunder-storms, so well studied out in Europe, and the distribution of tornadoes in cyclones, as discovered in this country, would be valuable additions to the series, but they were doubtless considered and excluded in order not to increase the size and cost of the atlas unduly. The same may be said of the cold waves in the Mississippi valley and the fœhn-like chinook winds on the northeastern plains, so fully illustrated in our weather maps; but even without these, the atlas is a decided advance on others of its kind, and is clearly the best series of meteorological charts ever published. The data employed come down to 1884, and, except concerning the winds and precipitation, seem to be sufficient on charts of the size here used to hold good for years to come over a large part of the world. The printing and coloring are beautifully executed, and worthily represent the high class of work done by the publisher, Perthes, of Gotha.

W. M. D.

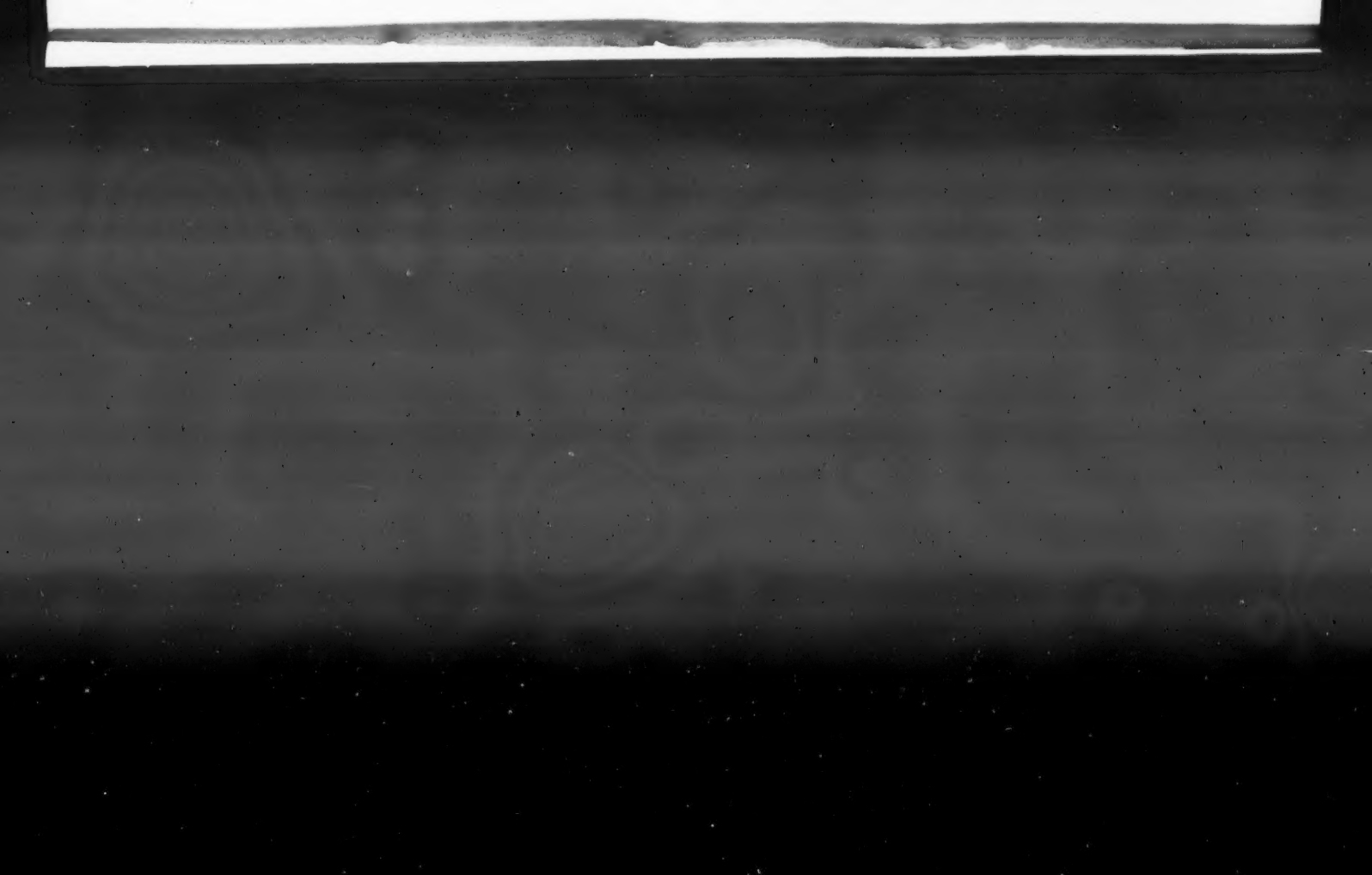
2. *New Meteorites.* (Communicated)—The U. S. National Museum has recently received fragments of two new Japanese meteorites from the Educational Museum at Tokio. Both are grayish stones, showing a dull black crust. The first of the two fell at Fukutomi, Kinejima, Province of Hizen, March 19, 1882, at 1 P. M. Its total weight was 7680 grams. The second fell at Maêmê, Hislugari, Province of Satsuma, Nov. 10, 1886, at 3 P. M. Its original weight was 328 grams.

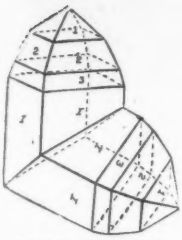
These specimens and the information regarding them were received from Prof. S. Tegima, Director of the Tokio Museum.

F. W. CLARKE.

West Coast Shells: a familiar description of the Marine fresh-water and land Mollusks of the United States found west of the Rocky Mountains. Adapted to the use of schools, private students, tourists and all lovers of nature; by Josiah Keep, A.M., Prof. Nat. Sci. Mills College. 230 pp. 16mo, with numerous illustrations. San Francisco, 1887 (Bancroft Brothers & Co.)—A convenient little work for the young student and collector of shells on the Pacific border.

Annual Report of the Geological Survey of Arkansas for 1887, by John C. Brauner, Ph.D., State Geologist, Little Rock, Arkansas, 1887. 15 pp. 8vo. A brief report of progress.





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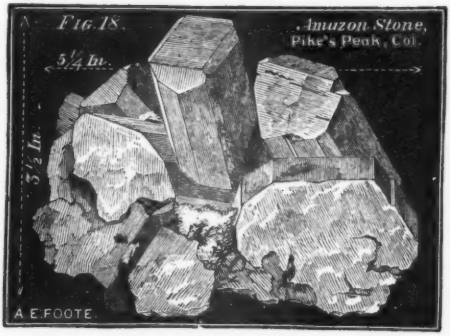

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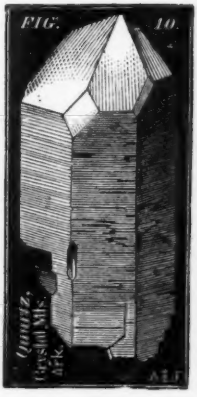

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